RADIO and ELECTRONICS

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OUR COVER

This month we show a view of the five-valve vibrator-operated receiver which has been described in this and the previous issue of "Radio and Electronics."

AN APOLOGY

Readers of the Philips Experimenter will note that this month's edition does not continue with the description of the modulator for the 100-watt transmitter. We wish to apologise to those who have been following this feature, and to assure them that the omission is one that is outside our control and that the series of articles on the transmitter will be continued next month.

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The Editor,
"Radio and Electronics,"
Box 22,
Government Buildings P.O.
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OFFICES AND LABORATORY:

Radio and Electronics (N.Z.) Ltd.,
46 Mercer Street, Wellington.
TELEPHONE:
Wellington 44-919.

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Mr. J. Kirk,
No. 11 Keans Building,
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GUY E. MILNE

A PROBLEM TO BE SOLVED

In the September, 1949, issue of this journal we published an article on the control of models by radio, written by Mr. L. H. Wright. of Wellington, who has done much development work over a period of years and has perfected a system of control that is essentially similar to the basic one of Hull, but which has certain advantages over the method still used in America. The chief of these is that a relatively robust relay can be used, with consequent improvement in reliability. However, there is still considerable room for improvement of the gear used, Mr. Wright says. Models such as yachts or sail-planes, which have no motors to cause vibration, can be controlled with complete success by the receiving equipment Mr. Wright has already developed, but difficulties occur when model petrol or "diesel" engines are carried. Perhaps we should say "a difficulty," because the trouble springs from none other than our old friend (or bugbear), microphonics. Apparently, insulation of the receiver by shock-proofing provides only a partial answer, and cases can be cited of control failing due to the appearance, or for no apparent reason, of a period of vibration which coincides with some particular resonance of the receiver, or part of it. The difficulty is a very real one, for the receivers used must, if possible, use battery-type valves, which are more microphonic than heater-cathode types. When this fact is remembered, in conjunction with the extremely high sensitivity of the receiver, it is clear that the problem is a major one.

We mention it here because there are, no doubt, numbers of our readers who could take an active interest in attempting to solve problems such as this, and who would be quite keen to do so, given the problem. Radio is recognized as a very fine hobby by large numbers of people, and the building and operating of models of all sorts is a hobby which probably has many more devotees than has radio. Since very few seem to take an active interest in both pastimes, those model builders who would like to control their models by radio very seldom have the necessary radio knowledge to tackle the subject themselves, and must rely on the assistance of someone who "knows about radio."

It seems to us that the subject we are discussing can very well be the means of providing wider interests and activities for a number of people, to the mutual benefit of all. At the same time, radio control is such a specialized branch of the subject that very few radio men have any practical knowledge of the problems involved.

Undoubtedly, there are other ways of achieving the desired end than those outlined by Mr. Wright in his article. It may be that someone who reads this article has the germ of a new and improved control system waiting to be developed. It may occur to someone else to solve the problem of microphonics that we have stated above; we would most earnestly exhort anyone who is interested to try something and see just what can be done, and, if success is attained, to write and let this journal know, so that other workers can be informed through these pages. Mr. Wright is anxious—and rightly so, we think—to awaken interest in this most intriguing side-line of radio application. He is an expert model builder and a radio man as well, and is in a position to pass on to the model-building fraternity any ideas that interested radio men, who are not model builders themselves, may be able to produce.

In asking readers to take an active interest in this question, we are really issuing a challenge. The fact is that commercial radio control receivers are available in the U.S.A. and in England, but the indications are that a sufficiently reliable system has not yet been produced—at least, for the specialized case of engine-powered model aircraft. If anyone can develop a really significant improvement upon present-day techniques, his will become a name to conjure with the world over!

Nor should the mistake be made of thinking that these matters are for boys and youths, and not to be taken seriously. Remote control—and particularly remote control by radio—is a subject which today can have literally world-shaking repercussions, and it is a subject that is being pursued continuously in research laboratories throughout the world—and not for fun, either. Let us point out that this does not mean that amateurs or those with limited laboratory facilities cannot make any useful contributions. This has never been so, and probably never will.

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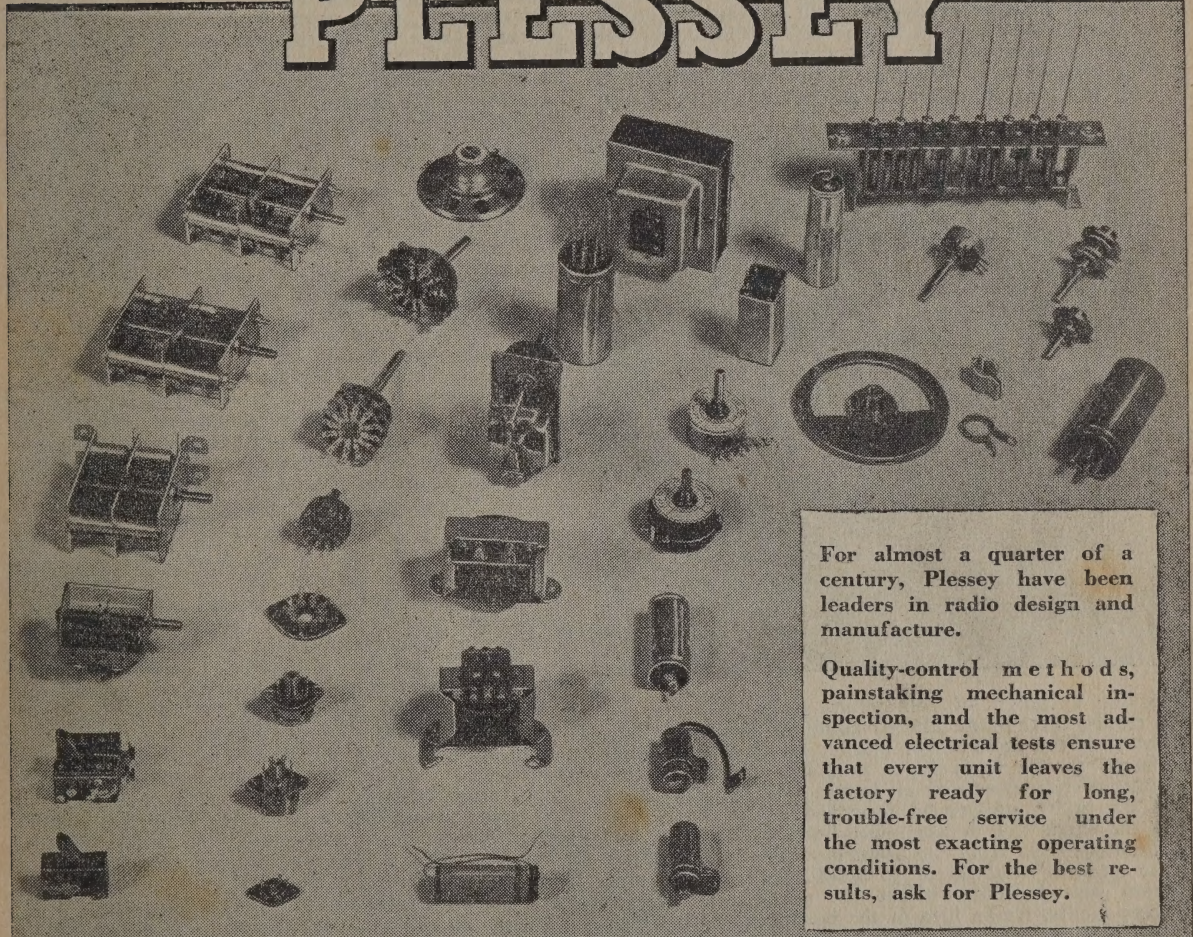

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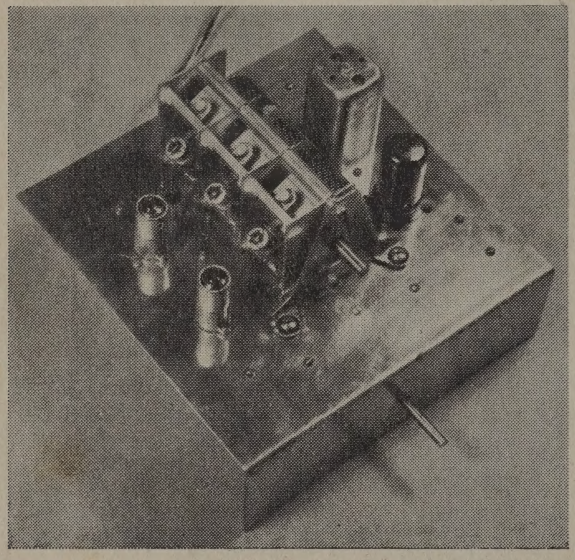
THE 80-40-20 BANDSPREAD TUNER

The tuning unit described in this article represents a radical departure from conventional bandspread tuning units, and utilizes a new method of obtaining complete spreading of narrow wavebands. The principle referred to enables the required frequency stability and bandspread to be obtained entirely without the use of special components such as negative temperature-coefficient condensers, and brings bandspreading within the scope of the amateur constructor.

INTRODUCTION

One feature that is almost universally desired by amateurs in their receivers is full bandspread on all amateur bands covered by the set. Hitherto, the design of a receiver which will provide this facility has presented so many difficulties that amateurs have been only too pleased to leave the question to be solved



by the designers of commercial units and sets. As a result, there is an almost complete lack of tuning units on the commercial market which can be purchased as the basis for a complete receiver incorporating full spread on all bands. The principle used in the tuning unit to be described below is not new in the sense that it has never been used before, but definitely is so from the point of view that it enables the amateur constructor to build a fully-spread unit from scratch, and without the use of any special components. As an idea of the basic ease with which this unit can be built, it can be stated that the prototype, of which photographs appear in these pages, was designed and built, from a standing start, in less than a week. When it is realized that the work involved in its development is many times that entailed in its duplication, and that all coils had to be made by hand, and individually adjusted, it can be seen that even the initial design held no particular difficulties. This, we hope, will encourage amateur constructors and others to attempt something along the same lines, for there are no great difficulties to be overcome, either electrical or mechanical, as long as a reasonably rigid and tidy job is made.

WAVEBANDS COVERED

When the idea for this tuning unit came to us, it seemed so immediately applicable to the requirements of amateur transmitters that it was decided to apply it first to a unit which covers the three main medium-high frequency amateur bands—80, 40, and 20 metres. Unfortunately, for reasons which will appear in due course, it was not possible to include the 10-metre band as well. This, however, was not considered to be an overwhelming disadvantage, since we ourselves have long since advocated the use of separate superheterodyne converters for getting the best results on the higher bands, including the 10-metre one. In order to simplify the construction, we have purposely refrained from including any general coverage bands, and have contented ourselves with achieving excellent performance on the amateur bands only. However, we would urge those readers whose interests may not lie in the amateur transmitting bands not to give up this article at this point, for exactly the same operating principle can be applied in building a receiver to cover some or all of the shortwave broadcast bands, with a full spread on all of them. Nor is there any inherent difficulty in adding to the system in such a way as to accommodate general coverage bands as well. **Unlike most shortwave tuning units, there is no reason why home-made coils should not be built with complete success,** either for shortwave broadcast use or for amateur bands, as here.

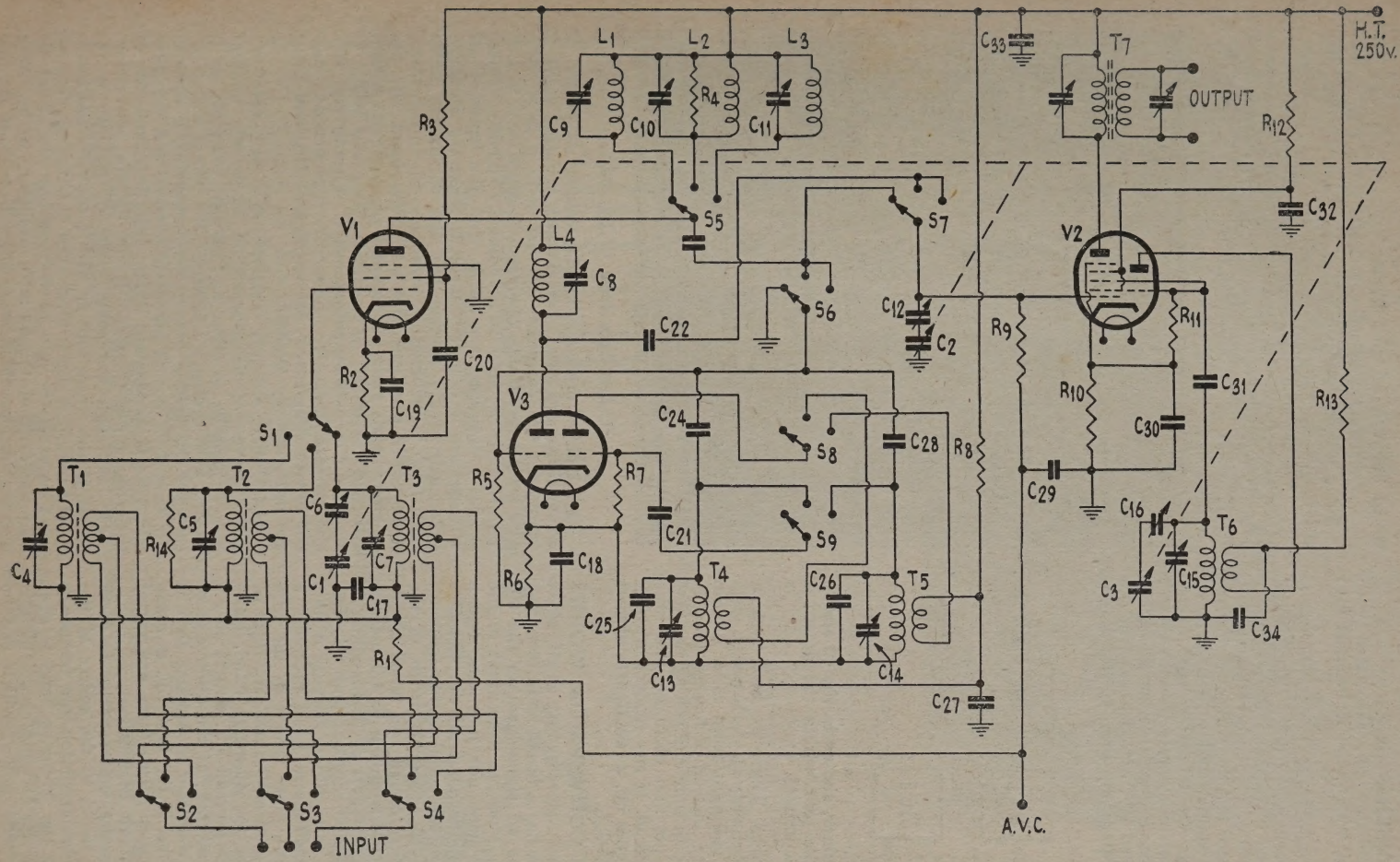
OPERATING PRINCIPLE

As we said above, the operating principle is not new. It has been used, in somewhat different ways, both in a well-known American communications receiver and in a Continental domestic set. In the latter, which was given a technical description in a recent issue of the "Wireless World," the principle was used to produce a set having broadcast, general coverage shortwave bands down to 13 metres, and, in addition, full bandspread on all shortwave broadcast bands up to and including the 13-metre band!

The system is this: On the 80-metre band (in our case) we have a perfectly normal tuner comprising an R.F. amplifier stage and an oscillator-mixer. The R.F. stage uses a 6BA6 miniature, which has a much higher mutual conductance than the usual full-sized tubes, and also a lower equivalent noise resistance. This valve therefore provides excellent gain and signal-to-noise ratio to the whole tuning unit.

On the 40 and 20-metre bands, the following circuit changes are made by the wave-change switch:—

(1) The 6BA6 R.F. stage is fixed-tuned at the centre of the band, and acts as a wide-band R.F. amplifier, whose gain is substantially constand over the whole band.
(2) The R.F. gang section is disconnected altogether, as it is no longer needed.
(3) The R.F. stage is fed not into the original oscillator-mixer valve, but to the input of an extra oscillator-mixer, not used when the unit is in the 80-metre position.
(4) The second section of the gang condenser that on 80 metres tunes the grid circuit of the original oscillator-mixer tube is disconnected from the 80-metre circuit in the plate of the R.F. stage, and is re-connected to a further 80-metre circuit which lives permanently in the plate cir-



COMPONENT LIST

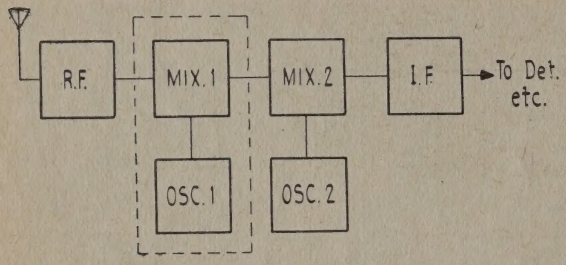
C_1, C_2, C_3, 420 $\mu\mu$f. max. cap. 3-gang.
C_4 to C_{16} inclusive, 3-30 $\mu\mu$f. Philips trimmer.
C_{17}, C_{19}, C_{29}, C_{30}, 0.05 μf.
C_{18}, C_{22}, C_{23}, 0.002 μf.
C_{20}, C_{27}, C_{32}, C_{33}, 0.1 μf.
C_{24}, C_{28}, twisted hook-up wire (see text).
C_{25}, 100 $\mu\mu$f. mica.
C_{21}, C_{26}, C_{31}, 50 $\mu\mu$f. mica.
C_{34}, 0.02 μf.

R_1, 100k.
R_2, 100 ohms.
R_3, R_4, R_{11}, 50k.
R_5, R_9, 500k.
R_6, 3k.
R_7, R_{13}, 20k.
R_8, 75k.
R_{10}, 150 ohms.
R_{12}, 25k.

cuit of the extra oscillator-mixer.

(5) A fixed-tuned oscillator coil associated with the extra oscillator-mixer tube is brought into action.

All this sounds very complicated, but in practice it is not, for, in the new position, all these changes boil down to (1) a fixed-tuned broad-band R.F. amplifier which feeds the signal grid of (2), an oscillator-mixer, whose fixed-tuned oscillator has the correct frequency to convert the 40 or 20-metre band to a first intermediate frequency within the 80-metre band. After this, the original oscillator-mixer valve, which is still working, converts the signals, which now lie in the 80-metre band, to the fixed I.F. of 455 kc/sec. in the usual way. The block diagram, Fig. 1, shows the



Block diagram of the tuner, shown in the 40 and 20 positions. On 80, the part within the dotted line is unused.

set up on 40 or 20 metres. Thus, we now have a double-conversion superheterodyne. However, this works in a way that is different from most double superheterodynes, for here, instead of having a fixed-tuned first intermediate frequency and tuning the first oscillator, we fixed-tune the first oscillator and tune the first I.F. amplifier instead. If any readers are still doubtful as to just what goes on, a few figures should make things clear.

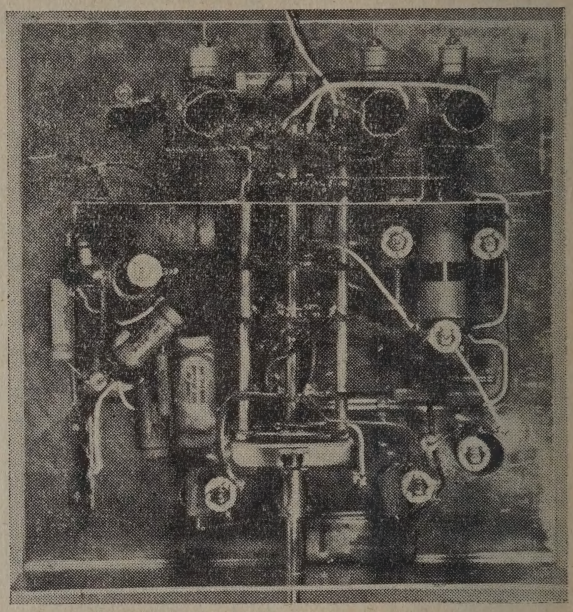
HOW THE DOUBLE CONVERSION WORKS

The R.F. stage takes no understanding at all, apart from remembering that it has a broad-band response. That is to say, it passes all signals within the 40-metre band equally well. Thus, at the output of the R.F. stage, we have present not just one signal, selected by the R.F. amplifier, but all the 40-metre signals that are present in the aerial at the moment. These signals are fed into the grid circuit of the first mixer tube. In its plate circuit is a tuned circuit whose tuning can be varied from 3.5 to 4.0 mc/sec. The oscillator section of the first oscillator-mixer is tuned to a frequency of 3.40 mc/sec., and this frequency remains constant at all times. Because of this fact, each signal in the 40-metre band produces a different I.F. signal in the plate circuit of the first mixer. For example, a signal on 7.0 mc/sec., right at the low-frequency end of the 40-metre band, beats with the first oscillator to give an I.F. output on 3.6 mc/sec. A signal on 7.3 mc/sec., at the other end of the band, beats with the oscillator to produce an I.F. output of 3.9 mc/sec. Thus, if the first I.F. is made tunable over the range 3.6 to 3.9 mc/sec., any signal inside the 40-metre band can be received.

On 20 metres, exactly the same system is used. Here, the R.F. stage is tuned to the centre of the 20-metre band, and the fixed oscillator to a frequency of 10.45 mc/sec., so that the 20-metre band is converted to the range 3.55 to 3.95 mc/sec., which is again tunable by the second mixer, which can be tuned between 3.5 and 4.0 mc/sec.

ADVANTAGES OF THE SYSTEM

Since the scheme is a somewhat unusual one, it is reasonable to expect it to have several advantages over the conventional bandspreading arrangement. Otherwise, it would hardly be justifiable, however elegant it might appear. There are, in fact, quite a number of advantages to be gained, and these are outlined below.

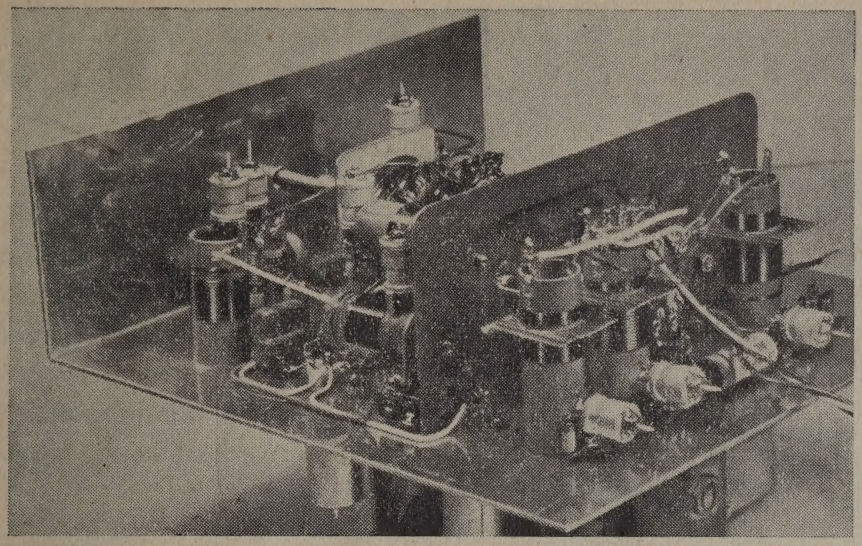


Underneath view of the unit.

(1) Unlike ordinary bandspreading schemes, in which series and parallel condensers are used in order to restrict the coverage obtained with a large variable condenser, stable operation is very easy to get. The stability we refer to is frequency stability. Unless special precautions are taken with the conventional arrangement, it is quite difficult to make the oscillator sufficiently stable so that the dial calibration holds right from the moment of switching on. In bad cases, it is not unusual to find a narrow band like the amateur bands right off the dial when the set is first switched on unless extra precautions are taken to stabilize the oscillator frequency. Commercial sets always use negative temperature-coefficient condensers to compensate for oscillator drift, and these are not generally available.

(2) Unlike ordinary systems, this one gives an equal degree of bandspread on all bands, without careful juggling of series and parallel trimmers, as is needed with ordinary schemes. This comes about because of the double conversion, for tuning is done at the first I.F., not at signal frequency, and this first I.F. band is of constant width, quite independently of the frequency of the signal before the first conversion.

(3) Although the same order of stability is required in the whole unit as with a conventional bandspread unit, it is much more readily obtained, because the first oscillator is a fixed-frequency one. There is also the drift of the variable oscillator to be taken into account, but this is very slight because of the low



Further underneath view of the unit, showing the aerial coils in the front of the photograph. The Faraday shields can be clearly seen.

frequency on which it works, and can easily be made negligibly small. A further advantage is that it is possible to place the first oscillator, as we have done, LOWER in frequency than the signal instead of higher, as in a conventional set. This again helps to increase the frequency stability. If one happens to have a crystal of the right frequency for the fixed oscillator, this can be used with a still further increase in stability, but this is by no means necessary, as results with the prototype showed.

(4) Although we have placed this last on the list, it is by no means the least important, since it places the construction of a bandspread unit within the scope of the amateur constructor. It is this: There is no question of constructing oscillator coils so as to obtain three-point tracking over a wide band, as occurs where spread bands are made an offshoot, as it were, from a normal general-coverage band. The only circuits which have to be tracked are the 80m.

(Continued on page 42.)

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Needle Tip Radius	0.00027 inches
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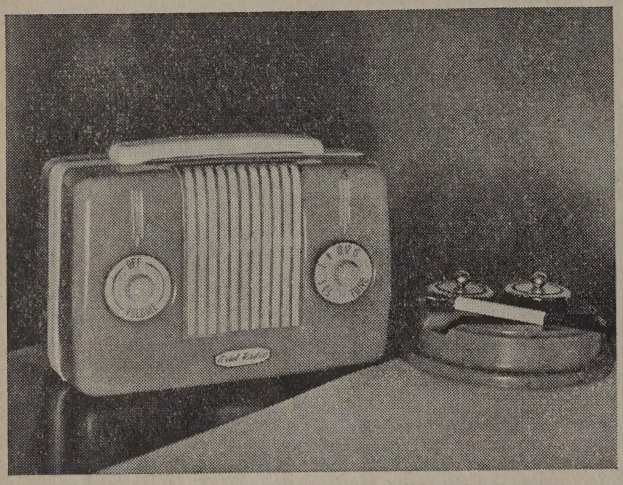

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PART 2: THE RECEIVER

The receiver circuit is simplicity itself. The single turn loop of wire forms a quarter-wave section of transmission line, short-circuited at the end remote from the valve. The actual length is much shorter than a quarter-wave line would be, because of the capacity shunted across it by the valve. The same thing goes for the length of the half-wave line for the transmitter. This is loaded by valve capacity at each end. The receiver oscillator circuit is similar to the transmitter one in many respects. For example, it also has its cathode up in the air to R.F., and here again an R.F. choke is used in the cathode circuit. However, special precautions were not found necessary as far as isolating the heater circuit was concerned, and we were able to earth one heater terminal directly to the chassis. On the receiver circuit is a diagrammatic representation of the method used to secure continuous tuning of the receiver over the band. A small vane of aluminium (or other metal) is made to approach the shorted end of the line until it is close as it will go without short-circuiting it. By this means a smooth frequency variation is obtained, and also one which does not tend to put the super-regenerative detector out of oscillation. In the illustration, the mechanical means for doing this can be seen. The pointer-knob drives a small planetary reduction drive, to the other end of which is attached a short length of $\frac{1}{4}$ in. brass rod. To the end of this is screwed a short length of perspex. On the end of the perspex is the vane, shaped so that when it swings over fully to the left it covers approximately $\frac{5}{8}$ in. of the line, measuring from the rounded loop at the end. The vane is attached at such an angle that it approaches to within a sixteenth of an inch or so of the line. The frequency scale given by this arrangement can be seen in the cover photograph, and it is nearly linear.

The idea of using a reduction drive is to open out the scale, since the amount of vane movement that is effective is only about 60 deg. The reduction drive, with the pointer attached, not to the slowly moving inside shaft, but to the fast-moving drive shaft, amplifies this movement and effectively gives a scale movement of about 180 deg. The planetary drive mechanism is mounted to the chassis on a small bracket made out of thin aluminium sheet. The grid leak and condenser are placed so as to form a continuation of one side of the line, just as drawn in the circuit diagram. Connecting the grid leak back to H.T. instead of to cathode or earth improves the super-regeneration.

SPEECH AMPLIFIER AND MODULATION

It is here that a little ingenuity had to be called into play in order to simplify the switching as far as possible. T_2 is the microphone transformer, and at the same time its secondary does duty as an audio choke for coupling the detector output to the speech amplifier tube, V_4. By this means, the gain control, R_2, is made effective on both transmit and receive, without altering any connections, and all that has to be done as far as the microphone is concerned is to switch it on. This is done by switch (b). At the same time, switch (a) either opens or closes the circuit of the detector. Thus, on "transmit," the transformer acts as a step-up for the microphone output voltage, while on "receive," the secondary acts simply as an audio choke, the primary winding being open-circuited because the mike switch is open. The speech amplifier is resistance coupled to the modulator, V_5, which also acts as an output valve on "receive." The transformer, T_1, is a step-down, for matching the low-impedance phones used, and its primary also acts as the modulation choke on "transmit."

V_4 is a 3S4, while V_5 is a 3V4. This may seem a peculiar choice of valves until it is explained. First of all, in order to use low-drain filament-type valves in the audio section and thus keep the A battery drain down as far as possible, we have to use two valves with 3-volt filament connections. Since no voltage amplifier exists which has a 3-volt filament, it was necessary to use a power valve, resistance coupled. It will be noted that the filaments of V_4 and V_5 are in series across the 6-volt A supply, and that, because it was thought that most often this would come from a 6-volt accumulator, a small resistance, R_8, was inserted in series to take care of the fact that a newly-charged battery measures 6.6v. Also the resistor, R_4, is added across the filament of V_4 in order to bypass the plate current of V_5, which otherwise would all flow through the filament of V_4 and be a further cause of possible over-voltage on its filament. The 3V4 was chosen for the modulator because it may be operated with 90 volts on plate and screen, whereas the 3S4 is only allowed a maximum of 67.5 volts on its screen. Also, the power output of the 3V4 is greater than that of the 3S4. R_6 is inserted between the two valves because this gives slightly more bias for the 3V4 than if it were on the positive side of the latter's filament. Bias for V_4 is obtained by the grid leak method, this being the reason for the double R.C. coupling between the primary of T_2 and the grid of V_4. There are no further points about the audio section that need elucidation, since the circuit is quite straightforward apart from the filament circuit. The microphone, which was a ZC1 carbon type, obtains its current directly from the A battery, without any series resistance.

MECHANICAL ARRANGEMENT

The mechanical arrangement can best be seen from the photographs. The detector and two audio stages are built in a row along the front of the chassis. The latter is bought with the small box, which is a commercial unit, and measures $6\frac{1}{2}$ in. x 4 in. x 5 in. high. The send-receive switch is in the centre of the chassis, and the other main parts can be easily seen in the underneath photo. The transmitter circuit is not built on the chassis at all, but is mounted all on the back panel, which unscrews from the box. After transmitter and receiver have been wired up separately, the panel can be screwed on to the back of the chassis and the interconnecting leads taken through a rubber grommet in the centre of the chassis near the back. The dirty appearance of the front

(Continued on page 11)

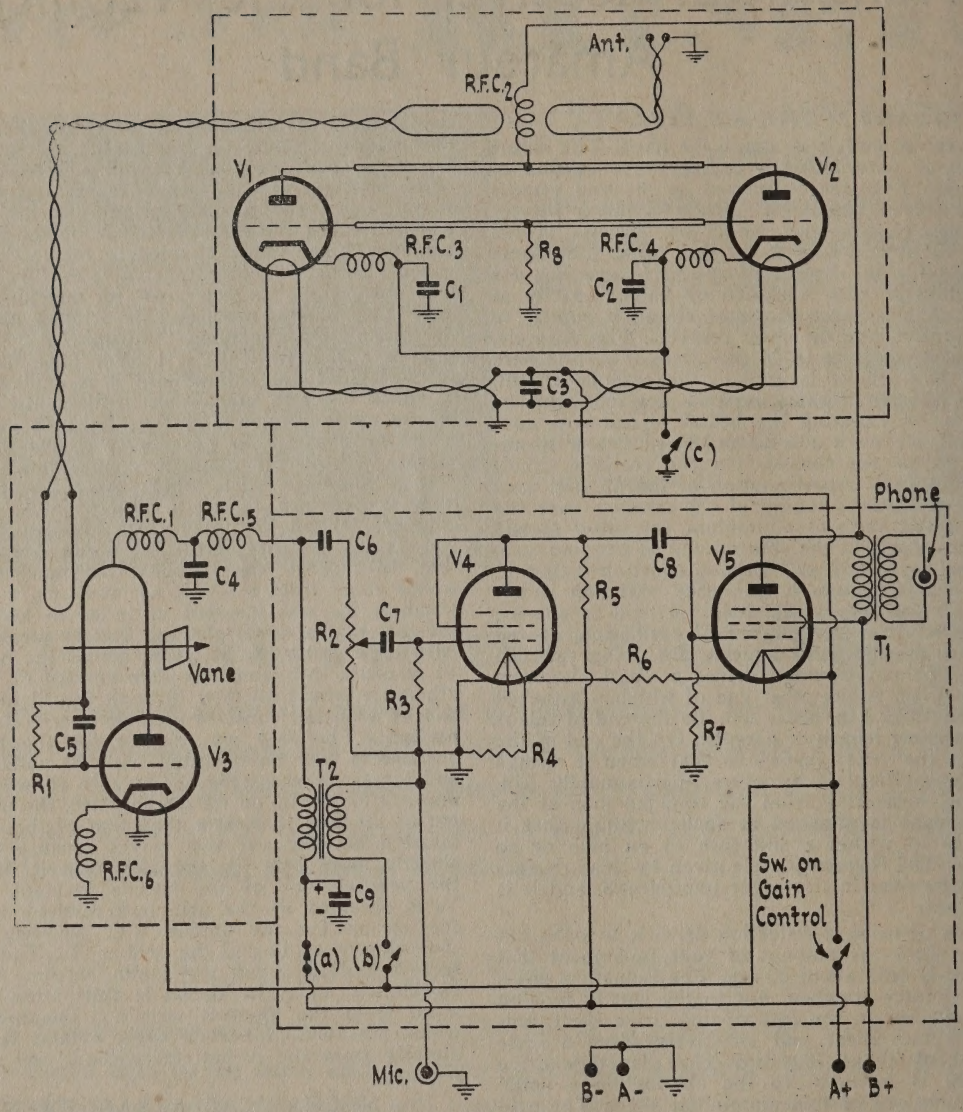

Fig. 1

COMPONENT LIST

V_1, V_2, V_3, 955.
V_4, 3S4 or 3V4.
V_5, 3V4.
RFC_1, RFC_2, RFC_3, RFC_4, 12 turns of 20-gauge en. wire, ¼ in. diam. form.
RFC_5, 10 mH. b/c choke.
RFC_6, same wire, same diam. form as RFC_1, etc., but only 6 turns.
R_1, 500k.
R_2, 500k. pot.
R_3, 10 meg.
R_4, 500 ohms.
R_5, 250k.
R_6, 10 ohms.
R_7, 1 meg.
R_8, 5k.
C_1, C_2, C_3, 15 $\mu\mu$f. midget silvered ceramic.
C_4, 0.004 μf. mica.
C_5, 30 $\mu\mu$f. (two $\mu\mu$f. midget silvered ceramics in parl.)
C_6, C_7, C_8, 0.003 μf. paper.
C_9, 16 μf. high-voltage electro.
T_1, T_2, see text.

(Continued from page 9)

of the chassis near the volume control potentiometer is due to the soldering of the shaft of this component to the front edge of the hole. This is necessary only to enable the shaft to be put through the hole in the front of the box, after which the nut is put on in the ordinary way.

We have already been asked why the 955 sockets of the transmitter portion are mounted in opposite directions. The reason is, of course, that there are no left- and right-handed valves made as yet, so that the sockets had to be mounted this way in order to bring plate and grid connections to the right side of the line. Because of the way in which the whole is put together, there is no difficulty about finding room above the chassis, as the general top-chassis photograph might tend to suggest. The only congested area is below the chassis, where most of the space is fully occupied, but not unduly so.

PUTTING THE SET INTO OPERATION

Since the set consists of three really independent units, and because the switching is so simple, there should be no difficulty at all in wiring them separately, and, for a start, making them work as independent items. In this way the transmitter can be used as a source of signal for getting the receiver working. In our case, we put the transmitting oscillator on 450 mc/sec. with the aid of Lecher lines, after which we were able to set the receiver frequency using the transmitter as a spot frequency check.

The first thing to do, then, is to decide on what frequency the transmitter is to go, and to set it to this with the Lecher lines. This procedure has been described many times in the literature, and more than once in these pages, but there will be no harm in recapitulating for the benefit of those who are not up in Lecher line procedure. First of all, a meter is placed temporarily in the earth return of the grid leak, so that it measures the oscillator grid current. The Lecher lines are then coupled to the oscillator by making a closed loop of flexible wire, twisting a few feet of it together into a twisted pair, and soldering the end to the end of the Lecher wires. The loop is then coupled to the oscillator lines near the centre point, in such a way that when a short-circuiting bar is run along the Lecher wires, a series of dips can be seen in the grid current as the lines pass through successive resonant points. If the coupling is too loose, no dips—or only very slight ones—will be seen, but if the coupling is too tight the oscillator will be pulled out of oscillation each time the Lecher line passes through resonance. The coupling should be adjusted so that an easily seen, but quite small, dip is observed. It is then an easy matter to locate the exact point of minimum grid current as the shorting bar is slid along. The apparatus is now all ready to take a frequency measurement. The shorting bar is adjusted to the precise spot where minimum grid current occurs, and this point is carefully marked. The bar is then slid farther along the line to the next spot where a dip occurs, and this one is carefully marked. The distance between the two marked points is then measured, preferably in centimetres, and it is then an easy matter to work out the frequency. For readers' convenience, it may be mentioned that 420 mc/sec. is a wavelength of 71.4 cm., and 460 mc/sec., the other end of the band, is 65.2 cm., so that, since the points marked on the Lecher lines are one-half wavelength apart, the distance for 420 mc/sec. is 35.7 cm. and for 460 mc/sec. 32.6 cm.

The frequency of the transmitting oscillator is adjusted by altering the spacing between the ¼ in. rods of the half-wave line, and not by altering their length. Quite a range can be covered without resorting to cutting bits off the rods; the frequency is higher the closer the spacing, because the effective shunt capacity remains the same, and it is well known that as the characteristic impedance of a piece of line is lowered, so a given amount of shunt capacity has a smaller effect on the frequency to which the line tunes. Using ¼ in. rods instead of lighter ones enables a fair degree of spacing variation to be obtained, simply by soldering the rods to one edge of the socket lug or the other.

The only ticklish adjustment about the whole thing is that of getting the receiver to tune over the band. However, if the transmitter is used as indicated above, there will be no difficulty about this. The Lecher lines can be used for adjusting the detector also. This time, the grid current cannot be measured, so the resonant points on the Lecher lines are spotted by listening to the super-regenerative hiss in the headphones and noting where the line pulls the detector out of super-regeneration. This point can be made quite sharp if the coupling between the Lecher line and the detector's tuned circuit is adjusted carefully. With too tight coupling, the detector goes out of super-regeneration over quite a few inches of shorting-bar movement, but with the correct coupling, the spot is very critical, and accurate frequency measurement is possible.

The receiver line is made from a piece of 16-gauge tinned copper wire. The distance from the plate lug on the socket to the top of the hairpin loop is 1½ in., and the distance between the sides of the hairpin is ¾ in. The grid condenser of 30 $\mu\mu$f. is made from two midget 15 $\mu\mu$f. tubular silvered ceramic condensers. These were used because of their extremely small size and low inductance. They and the ½-watt grid leak resistor are wired in parallel and mounted vertically on the grid connecting lug on the socket of the 955. The unit thus formed is only half an inch long, and replaces the lower half-inch of the hairpin loop that would be there if the condensers and resistor were omitted. If the hairpin is made according to specifications, the frequency will be found to be very close to the band, if not in it. The first step in the adjustment is to check the frequency of the detector with the vane absent. It must be remembered that, with the vane removed from the vicinity of the loop, the LOWEST frequency is obtained. As the vane is swung over to cover more and more of the closed end of the loop, the frequency rises, and is at a maximum when fully over the loop. The next step is therefore to adjust the frequency of the detector to 420 mc/sec., with the vane away from the loop.

This can be done by very slightly squeezing together, or spreading apart, the sides of the hairpin. Closing the spacing raises the frequency, as with the transmitter. This should be done carefully, as a difference of a thirty-second of an inch shifts the frequency several megacycles. When the low-frequency end of the band is reached in this way, the loop is left untouched, and all further adjustment is made by altering the size and spacing of the vane. In the prototype, the working part of the vane was made spade-shaped, as can be seen in the photograph, to correspond with the shape of the upper part of the hairpin loop. It measured ⅝ in. from the top of the semi-circle to the bottom of the spade, and, when in final position, was spaced one thirty-

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second of an inch from the loop. The loop is bent very slightly backwards, because the movement of the vane is circular, so that in its closest position to the loop, it and the loop are parallel. If too much or too little frequency variation is obtained, either the spacing can be adjusted or else a little can be lopped off the vane to make it a bit smaller. These adjustments may be a bit tedious if one is fussy about having the band exactly covered and no more, but there is nothing at all difficult about them. Frequency adjustment is very smooth, and the stability is very good. The photograph on the front cover shows how open and linear the frequency scale is.

THE AERIAL AND ITS COUPLING

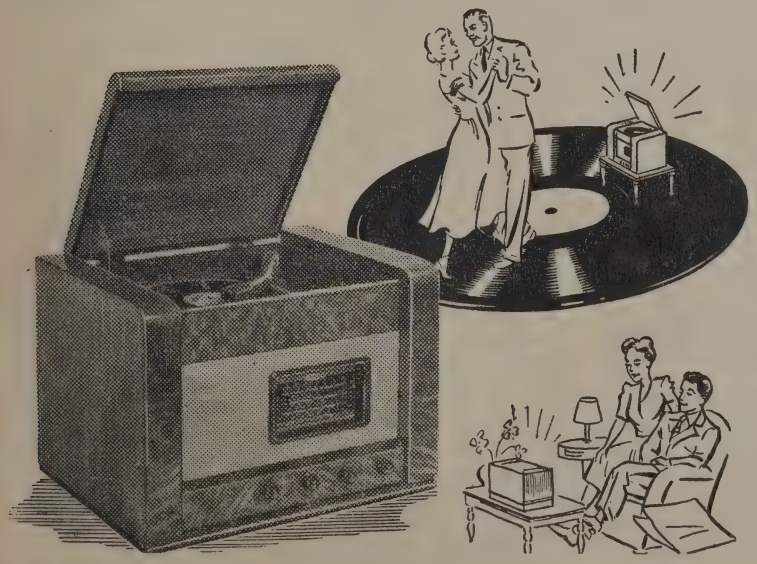
There is no restriction on the type of aerial to be used with this equipment, but a neat and easily made arrangement is the "flagpole" type of vertical aerial, shown plugged in the top of the box in the cover picture. A diagram of this aerial is shown on this page. It has been drawn as the type in which the skirt is made of four quarter-wave wires attached to the outer conductor of the concentric line, and bent back and down parallel to the line. The aerial illustrated in the photograph was exactly the same as this except for the fact that a quarter-wave piece of ½ in. brass tube was used instead, soldered to the top of the feed line by means of a copper washer, and spaced at the bottom with a small washer made out of perspex. The inner conductor of the feed line is made of 16-gauge copper wire, and is extended out to the end of the tube for a quarter wavelength to act as the radiator, ⅜ in. in conjunction with the skirt, which completes the half-wave dipole. The outer conductor of the feed line is made from thin-walled ¼ in. outside diameter brass tube, which makes a concentric line of approximately 70 ohms characteristic impedance, and therefore matches the aerial impedance quite well. In our case, the feed line was made 14 in. long, and only one internal spacer was used, made as a small washer from perspex. Perspex plugs were made for the top and bottom spacers. The whole thing is a very efficient aerial, and is very easily made with no more than a hacksaw, file, and heavy soldering iron.

Set in the top of the box is the face-plate of a wave-change switch, which, having a quarter-inch hole for its original shaft, makes a neat fit for the feeder line. The spring which normally bears on the ball was used to bear on the line and make a good electrical connection. The connection to the inner conductor was made by screwing a small block of perspex to the back panel. This block has a small hole drilled in it so that a pin-connector taken from a miniature valve socket is a tight fit in the hole. Just above this, a spring-brass collar is placed, in such a way that the outer conductor of the feeder line passes through it, making contact. The inner conductor pokes out about ¼ in. from the lower end of the line, and is sharpened to a point so that it slips easily into the valve-pin connector.

Coupling to the line is made with a short length of twisted pair, made from P.V.C. hook-up wire, and ending in a rectangular loop 1 in. long, and the same width as the spacing between the oscillator lines. One end of this loop is placed exactly at the

(Continued on page 48)

SALES ARE UP . . .



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A MODIFIED "BROADCAST DX 12"

By G. R. GILBERT

Readers will remember the original "Broadcast DX 12" which was described some time ago in these pages. The original circuit and mechanical details are also given in the "Radio and Electronics Digest of Circuits."

Lighthouses are notoriously isolated places, and on a lighthouse station the radio is the main link with the rest of the world. It provides most of the entertainment and all of the news. Therefore, when I was appointed to the light service a good radio receiver was one of the first essentials I considered.

Being often far distant from any transmitting station of any power and only in one or two cases being able to run off the 230-volt mains, the design of a suitable receiver presented special problems. On the score of distance, it was necessary for the receiver to provide ample sensitivity and a corollary of sensitivity that was selectivity. The power provided at the various light stations varies from 110 volts D.C. through lower voltage D.C. plants—32 volts, etc.—down to none. But on these last the lightkeepers usually provided themselves with a small 6-volt plant with a charging motor. Finally it was decided to run the receiver from a 6-volt storage battery together with either dry battery or vibrator "B" supply. Necessarily, this would limit the possible power output from the set.

It was quickly found that set designers generally had not considered it necessary to design a receiver of high sensitivity and fair quality for isolated districts—the majority of such receivers being either five or six-valve vibrator models or dry-battery sets ranging up to eight valves. Neither type of set offered much in the way of sensitivity or selectivity.

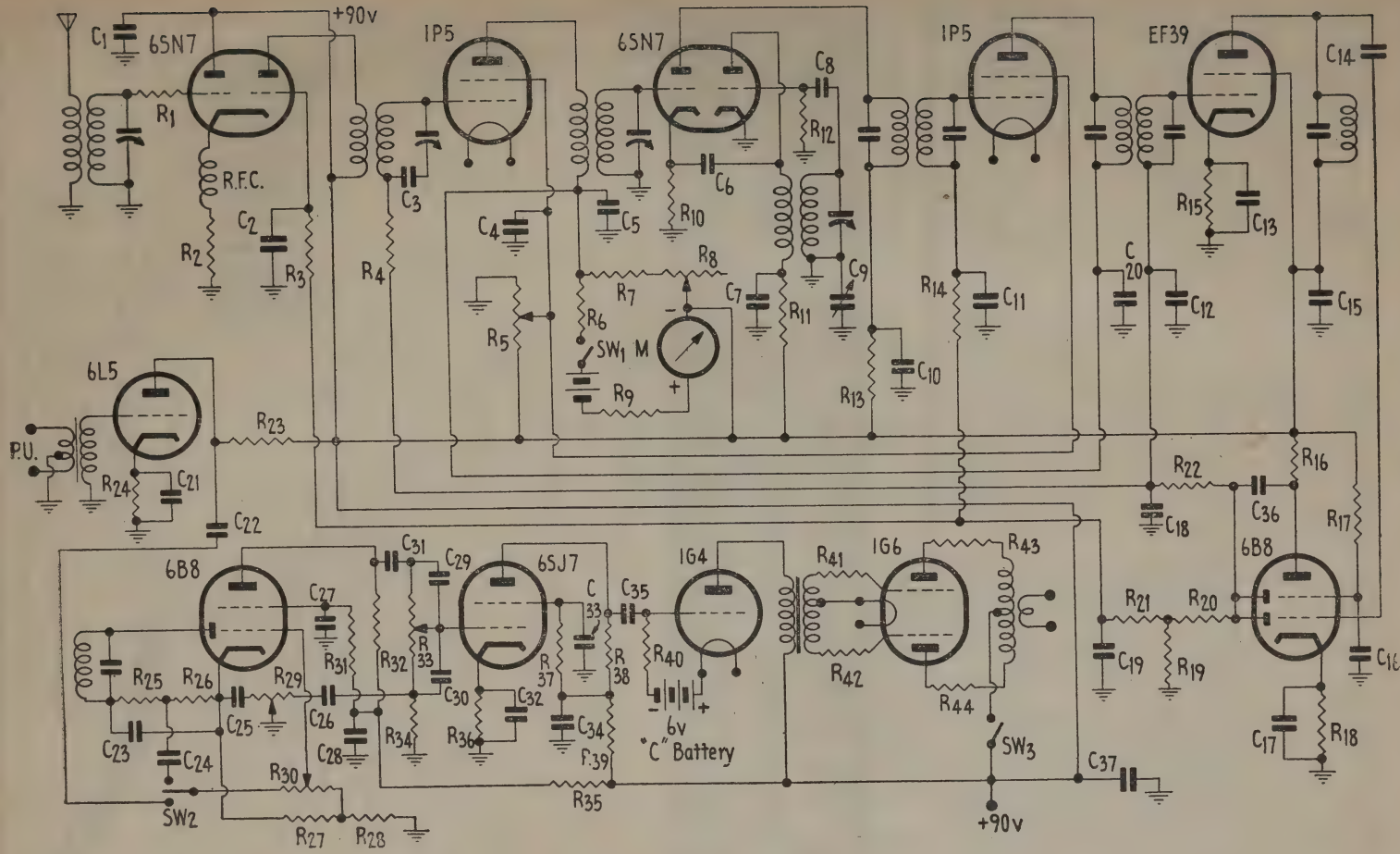
Finally it was decided to construct a modified version of the "DX 12," and the resulting 11-valve receiver produced was so satisfactory that this outline of it may encourage others who are far from both broadcasting stations and the 230-volt supply to construct a set which is far ahead of the average battery or vibrator models available to-day.

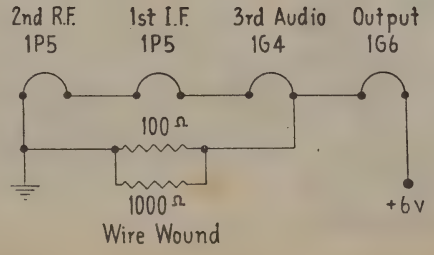
Running through the valve line-up finally chosen, it will be seen that the grounded-grid R.F. stage and the infinite impedance mixer have been retained, using 6SN7's, as was the second I.F. stage EF39, it being considered that no suitable light consumption substitute for the double triodes was available and that the signal amplitude present at the grid of the second I.F. stage would be too great for a 1.4-volt battery valve to handle.

The EF39 in the second R.F. stage was replaced by a 1P5, as was the 6SK7 in the first I.F. stage. The two valves in the A.V.C. amplifier were telescoped in a single 6B8, while, as the set was to be used primarily for ordinary domestic listening, the B.F.O. was omitted altogether. The 6H6, together with its noise-limiting circuit, was replaced by another 6B8 in the second detector socket. Faced with the considerable attenuation at high audio frequencies caused by the high selectivity of the I.F. channel, it was thought desirable to utilize the pentode section of the 6B8 as a simple tone-compensating circuit. This circuit—adapted from one appearing in the Australian periodical "Radio and Hobbies" some years ago—provides both bass and treble control, the former from the simple bypassing action of C_{29} and C_{30} across the bass control R_{33}, the latter from the bypassing action of R_{29} together with C_{25} and C_{26} in controlling the negative feedback across the cathode load resistor, R_{28}. As the only voltage passed on to the grid of the next stage is that developed across R_{34}, which is effectively paralleled by R_{29}, R_{27}, and R_{28}, the gain of the tone-control stage is, at the most, unity. To compensate for this, a 6SJ7 was used in the following stage. Finally the 6V6 output stage was replaced by a 1G4 driving a 1G6 twin-triode Class B output stage. This Class B stage combines lower plate current together with greater output and little more distortion than would be possible by using a pentode. The speaker is an eight-inch permanent-magnet enclosed in a vented baffle. As it was desired to use a low-output needle armature pick-up with the set, a triode amplifier, using a 6L5, was included to pass on the amplified pick-up output to the pentode section of the 6B8 tone-control stage.

Component List

R_1, R_{28}, 5k.
R_2, 200 ohms.
R_3, R_{12}, R_{14}, R_{16}, R_{19}, R_{20}, R_{25}, 50k.
R_4, R_{10}, R_{32} R_{38}, 100k.
R_5, 50k potentiometer.
R_6, 150 ohms.
R_7, 750 ohms.
R_8, 200 ohms wire-wound potentiometer.
R_9, R_{18}, 500 ohms.
R_{11}, R_{37}, 2k.
R_{13}, 1500 ohms.
R_{15}, R_{36}, 1000 ohms.
R_{17}, 60k.
R_{21}, R_{23}, R_{26}, R_{37}, R_{40}, 250k.
R_{22}, 1 meg.
R_{24}, 10k.
R_{29}, 50k potentiometer.
R_{30}, R_{33}, 1 meg. potentiometer.
R_{31}, 500k.
R_{34}, 7k.
R_{35}, R_{39}, 25k.
R_{41}, R_{42}, 300 ohms.
R_{43}, R_{44}, 30 ohms.
C_1, C_7, C_{13}, C_{22}, C_{24}, C_{26}, C_{30}, 0.05 μf. paper.
C_2, C_4, C_5, C_{10}, C_{11}, C_{12}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{20}, C_{27}, C_{33}, C_{35}, 0.1 μf. paper.
C_3, C_{25}, 0.02 μf. paper.
C_6, C_8, C_{23}, C_{36}, 0.0001 μf. mica.
C_9, padder.
C_{14}, 0.00005 μf. mica.
C_{21}, 0.5 μf. paper.
C_{28}, C_{34}, C_{37}, 16 μf. electrolytic.
C_{29}, 0.002 μf. mica.
C_{32}, 25 μf. electrolytic.
C_{31}, 0.05 μf.
R_{28}, 25k.





Filament Connections of 1.4-volt Valves

The inclusion of the S-meter presented some little difficulty, but finally a separate bucking voltage was provided by two Penlite cells in series to balance the meter which has been inserted in the plate return of the two A.V.C. controlled IP5's. The meter circuit is controlled by a switch on the bass control potentiometer, so that there will be no drain on the dry cells when the set is not in use.

It may be considered that more 1.4 volt valves could have been used in a series parallel filament circuit, with a consequent lighter filament and heater drain and a lower plate current. However, the use of 1.4-volt valves in a series-parallel filament circuit is inadvisable, as, if the filament of one valve opens, a high voltage is placed across any others in parallel, with a consequent loss of them also. In any case, most of the 6.3-volt valves draw little plate current, and it is no problem to provide the total heater circuit of under 2½ amps. from a storage battery. The total plate current at a voltage of 90 varied around 20 mills, according to the setting of the volume control. And it was found that with normal usage a pair of heavy-duty "B" batteries lasted from five to seven months. The use of a vibrator, of course, cuts out the high-tension problem, but the unavoidable residue of noise present reduces the usable sensitivity of the set.

Finally, it can be said that this modified version of the "DX 12" has been giving satisfaction here for nearly a year, and as an example of its performance it can be said that when the New Zealand broadcasting station frequency changes came into force and a new log was being compiled, **every** New Zealand broadcasting station, with the exception of 4XD, which was not on the air at the time, was logged in one evening at good listening volume.

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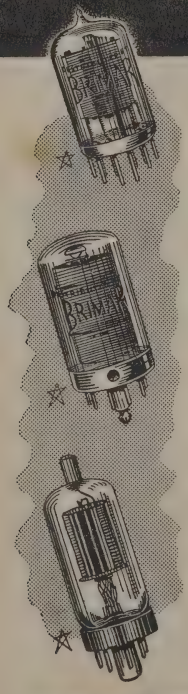

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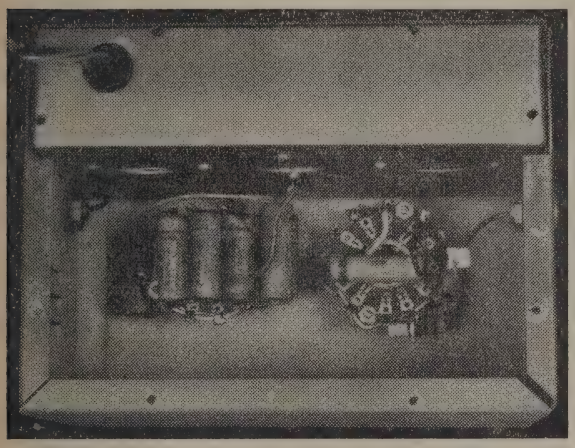
CONSTRUCTING THE "VERSATILE PRE-AMPLIFIER"

Since last month's issue we have had a number of requests for details of the construction of the gramophone pre-amplifier featured on page 11 of that issue. The accompanying two photographs show how our own original was made.

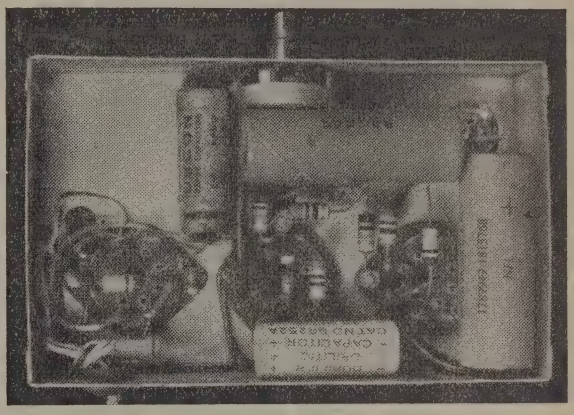
The pre-amplifier was constructed, minus its power supply, which was intended to be drawn from the main amplifier chassis, on a commercial chassis and cabinet. The chassis measures 6 in. x 4 in. x 1½ in., and the box into which it is made to fit is approximately 6 in. x 4 in. x 5 in. There is thus approximately 3½ in. of "headroom" for the valves and any other components that may be mounted above the chassis. In the photograph it will be noted that there are three valve sockets, whereas the circuit given in the October issue shows only two valves. The third



Looking into the back of the pre-amplifier

valve was a cathode-follower output stage, which may be omitted if desired. It will be seen that the switches and the components associated with them are mounted not on the chassis, which is hardly deep enough for a wafer type of switch, but directly on the front of the box. From left to right in Fig. 1 the valves are 6J7, 6SJ7, and 6C5 cathode follower. The input and output shielded sockets are mounted on the side of the box, and can be seen in the photograph. The leads to these and the switches are connected up after the unit has been completed otherwise, and slipped into the box. The power leads are taken in through a rubber grommet at the back of the chassis. In the underneath view, Fig. 2, a volume control can be seen on the chassis front. This was not shown in the original circuit, and was added between the pre-amplifier proper and the cathode follower stage in case the output of the pre-amplifier was too great for the main amplifier's gain control to handle satisfactorily.

Removing the switches and their networks from under the chassis is what enabled the unit to be built in such a small space without overcrowding underneath. The separate filament transformer for the unit was placed under the chassis of the main amplifier, where there was more room for it, rather than in the pre-amplifier itself. This also has the advantage of keeping a 230v. A.C. lead away from the unit, thereby minimizing direct hum pick-up. In Fig. 2, the right-hand valve is the output stage.



Underneath view of the pre-amplifier

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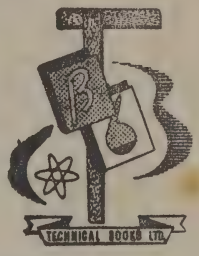

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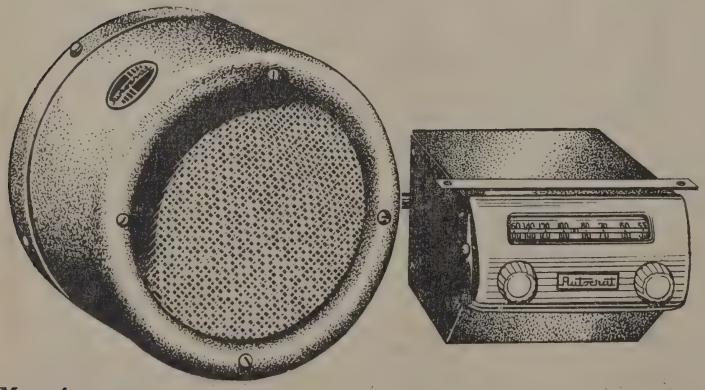

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QUESTIONS AND ANSWERS

SPEAKERS FOR USE WITH DIVIDING NETWORKS

"R.M.D.," Masterton, writes with a number of pertinent queries regarding our recent article on speaker-dividing networks. He points out: (1) The average small speaker is far less efficient than a good 12 in. speaker; will not this mean that the highs are reproduced at about a third the volume level of the lows, with the resulting effect a muffled one? (2) Briggs says that a real difference in flux density gives a loss of naturalness and balance due to the difference in "attack." (3) Is not the only real answer to this to buy a "tweeter" at about £15, including horn—much too expensive for most people? (4) As an alternative, if a small cone speaker is used as the tweeter, should this not be one with a high flux density, so that the effect could be reduced, although not completely eliminated? (5) Is there some way of compensating for this by varying the tappings on the auto-transformer used to match the small speaker to the dividing network? (6) Is the average small 6 in. or 8 in. speaker of sufficient fidelity to give any worthwhile improvement over a good single speaker? Would not the reduction in intermodulation distortion be offset by distortion introduced by the small speaker?

These queries raise fundamental points about the operation of dividing networks and dual speakers, so we shall not attempt to answer them piecemeal, but will add some general remarks to those already printed in our article in the August, 1949, issue of "Radio and Electronics."

The matter of speaker sensitivity was one which was not mentioned in the original article, and our correspondent is quite right in raising the points he has done. The original article perhaps did not stress sufficiently the fact that the best possible arrangement, to be used at all times if one can afford the expense, is to use a special "tweeter" of the multicellular horn type. These units are certainly dearer than small ordinary speakers, by a good deal, but one should consider very carefully whether a proper tweeter cannot be afforded. In fairness, however, whatever two speakers are used, unless both are by the same manufacturer and are matched for use with each other, one is likely to strike a certain amount of difficulty because of different power sensitivities in the speakers. In the case mentioned, where ordinary speakers are used for the tweeter, the low-frequency speaker's sensitivity is likely to be higher than that of the tweeter, but when a special tweeter is used there is no guarantee that there will still be no difference in the sensitivities. In this case, it would be quite possible for the tweeter to be the more sensitive of the two.

In spite of this, the difficulty is a real one, so that if the effect is very pronounced, something will have to be done about it. One way out of the difficulty is to provide the amplifier with independent bass and treble boost controls (which are a desirable adjunct in any case) and to use a certain amount of top lift if the tweeter is found to be much less sensitive than the low-frequency speaker.

As to whether the twin speaker arrangement, without a special high-frequency speaker, is good enough to give any improvement over a good single speaker, this depends to a large extent on the speakers themselves. The question cannot be answered unequivocally because there are so many variable factors involved. There is no good reason why a good 6 in. or 8 in. speaker should give any more distortion than even a fairly expensive 12 in. one in the higher register, while there are reasons why a small speaker, other things being equal, should be expected to produce less distortion at high frequencies. It is noteworthy in this respect that all specially designed high-frequency speakers are of the small diaphragm type. It can also be truthfully said that the most common reason for intermodulation distortion occurring in a large speaker is the fact that the cone does not vibrate in the same manner when excited at widely different frequencies. Harmonic modes of vibration can be set up in a large cone excited with high-frequency current, and the fact that the cone may be vibrating as a whole, at some lower frequency, at the same time, is sufficient to cause the high-frequency note to become modulated by the lower one.

With regard to frequency response, as such, it is not unreasonable to expect a small cone speaker to have a better performance than a large one at high frequencies, because the very factors that make a large speaker a good low-frequency radiator also militate against its being a good high-frequency reproducer at the same time. In particular, a light cone and a light voice-coil winding and suspension are features desirable for high-note reproduction, and it is a difficult matter to retain these and still build a large speaker that will handle low frequencies as well. A very noteworthy point in this connection is that one of the highest-priced and most-highly-thought-of English electric gramophones at the present time uses a simple scheme for reducing inter-

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modulation distortion, and this does not involve a dividing network at all. It is simply to use three identical speakers in series. The object of this is simply to reduce the level at which the individual speakers work, and to reduce intermodulation effects in the speakers by this means. Obviously, the lower the level at which a given speaker works, the more chance it has of operating in a linear fashion, so that dividing the power between three speakers, even if the full frequency range is fed to all of them, must reduce the amount of distortion arising in the speakers themselves.

We did not intend to lead readers to suppose that any small speaker is as good as a tweeter. This is obviously not so. Because of our policy of not recommending any particular make of component for a particular application, we had nothing to say about speakers that might be suitable, this being left entirely to the individual experimenter. However, it will do no harm to indicate what sizes should prove most satisfactory. As our correspondent pointed out, the tweeter should have a magnet which has as high a flux density as possible. This goes for any speaker, and especially for a tweeter. We would not recommend using a 10 in. speaker as the tweeter, although, as was said in the original article, a dividing network used with two identical speakers must necessarily give better results than a single speaker of the same kind, just as using two speakers in series or parallel is better than a single one. In fact, if one finds difficulty in getting a 6 in. or 8 in. speaker with a good enough high-frequency performance to use as a tweeter, one could do worse than use, say, two identical 10 in. speakers, or even 12 in. ones.

The whole business is one for individual experiment, and the system should not be condemned if one particular speaker does not act as a very good tweeter. The article originally published by us was rather intended as a basis for much interesting and inexpensive experimentation by our readers than as a cut-and-dried solution to a problem that has been exercising the best audio engineers for many years.

TROUBLE WITH AN OSCILLOSCOPE SHIFT CIRCUIT

"G.D.G.," Amberley, writes that he has constructed the 5 in. oscilloscope circuit published in the November, 1948, issue of "Radio and Electronics," and is experiencing difficulty with the shift circuit, in that the spot will move only a little way in one direction, but will move right off the screen in the other direction—on the same axis, that is. The trouble occurs on both X and Y axes, and changing the values has not cured it.

When the article in question was published, we did not say anything about the possibility of this sort of behaviour, although we knew it could take place. The trouble is that the circuit inherently gives a greater shift voltage on one side of zero than on the other.

One way out of the difficulty is to use a greater voltage across the whole network, so that, even though the effects on either side are unequal, each is great enough to shift the spot right off the screen. This was not done in the original design because doing so would have left less voltage for the C.R.T. supply. (It will be remembered that some of the total supply voltage is used to feed the shift circuit.) An alternative way out, which again was not made use of in the original design because of its cost, is to use a separate positive power supply for the positive half of the shift network. If, say, 400 volts positive is available from somewhere else, it can be applied to the positive end of the shift network, after which the negative end can be taken to a point on the C.R.T. supply that is 400 volts negative with respect to earth.

In spite of the disadvantage of the circuit in this respect, it still represents a means (and the only one we know of) of getting balanced shift voltages without the use of ganged potentiometers, which are, as ever, unobtainable.

WIRE FOR DIVIDING NETWORKS

A correspondent writes that he cannot obtain 20-gauge enamelled wire such as was recommended for winding the chokes for speaker-dividing networks, according to the winding chart given in our August issue. He inquires whether 20-gauge silk-covered or 20-gauge cotton-enamel would do instead of the 20-gauge enamelled that was specified.

The difference will be that, since the chart for the number of turns was drawn with reference to one type of wire only, the inductances obtained by using it with other wire sizes will not be quite correct. Our suggestion is that the wire with the nearest winding diameter, irrespective of the type of insulation (since this is unimportant) should be chosen, after which the number of turns laid down by the chart should be adhered to for a first trial. A check can then be made to see if the inductance is very different from the value required by the formula.

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TYPE SET—A.C. Superhetrodyne—self contained loop antenna.
TUBES—(six) 6SG7 R.F. Amp., 6SA7 converter, 6U7G I.F. Amp., 6Q7GT Det.-A.F., 6V6GT Power Output, 6X5GT Rectifier.
POWER SUPPLY—230 v. A.C. Rating, 40 watts.
TUNING RANGE—Broadcast, 540-1600 k.c.

ALIGNMENT INSTRUCTIONS

To set pointer, fully mesh variable condenser and set pointer at last reference mark at right end of dial. Set volume control as maximum and keep output from signal generator no higher than necessary to obtain output reading. Use insulated alignment tool for adjusting.

Dummy Antenna	Signal Generator Coupling	Sig. Gen. Frequency	Band Switch Position	Radio Dial Setting	Output Meter	Adjust	Remarks
.1 mfd.	High side to pin No. 8 (grid) of 6SA7. Low side to B —	455 Kc.	.....	High freq. end	Across voice coil	A1, A2, A3, A4.	Adjust for maximum output
R.M.A. Standard	High side to ant. term, low side B—	1400 Kc.	.....	Tune for max. output	"	C20	" "
"	"	600 Kc.	.....	"	"	C14	Rock variable and adjust for max. output.. Recheck C20 at 1400 Kc. If C20 is changed recheck C14.

CAPACITORS

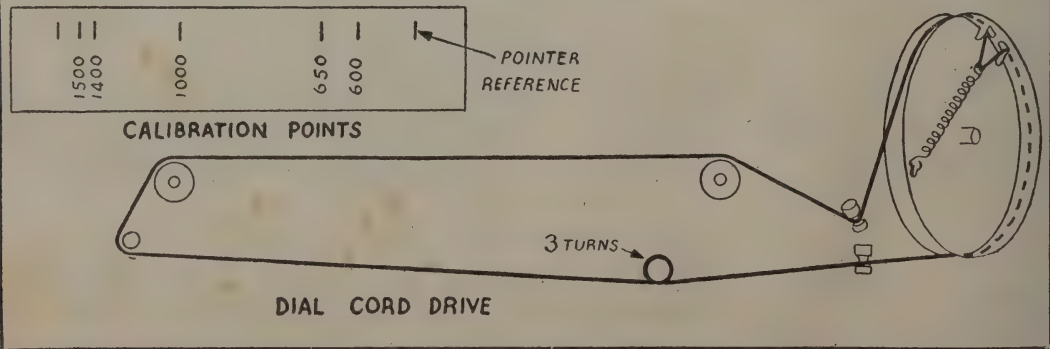
Ref. No.	Cap.	Volts
C 1	25mfd.	25
C 2	20+20mfd.	450
C 3	20+20mfd.	450
C 4	.1mfd.	600
C 5	.1mfd.	600
C 7	.1mfd.	200
C 8	.05mfd.	400
C 9	.05mfd.	400
C 10	.01mfd.	600
C 11	.01mfd.	600
C 12	.004mfd.	mica
C 13	.0005mfd.	mica
C 14	600mmfd.	padder
C 15	.00025mfd.	mica
C 16	.0001mfd.	mica
C 17	.0001mfd.	mica
C 18	.00005mfd.	mica
C 19	3-30	trimmer
C 20	3-30	trimmer

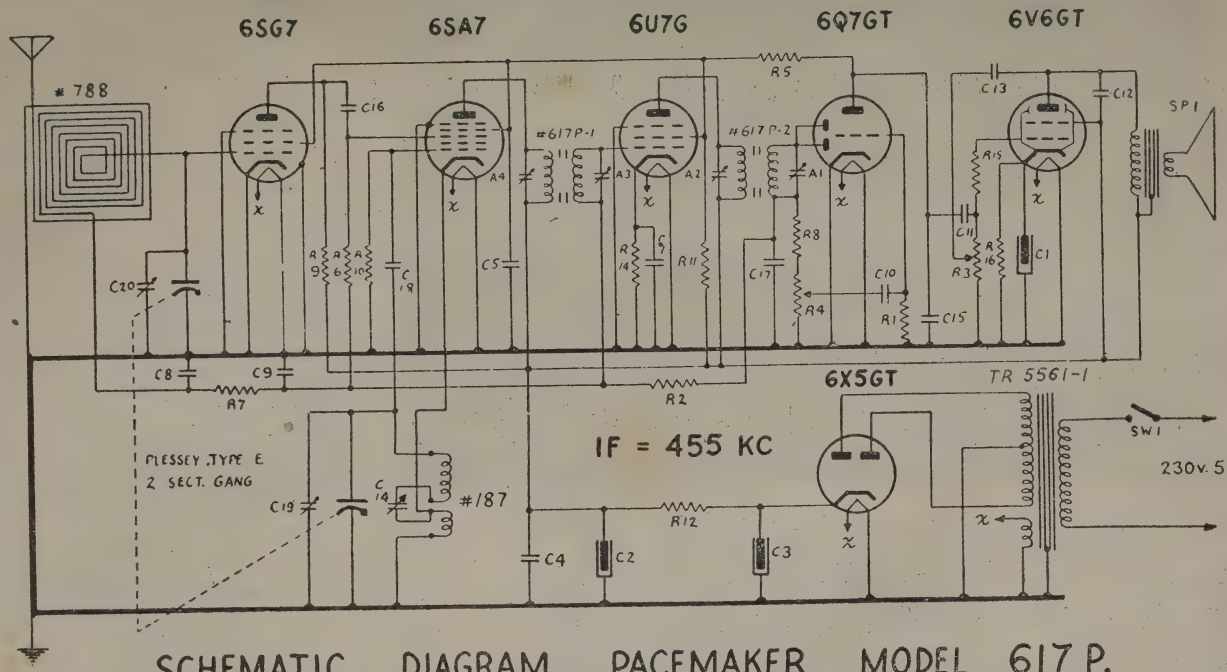
MISCELLANEOUS

Ref. No.	Res., Pri.	Res., Sec.	
788	.04 ohm.	.66 ohm.	
187	.24 ohm.	2.44 ohm.	
617p-1	6.75 ohm.	6.75 ohm.	
617p-2	6.75 ohm.	6.75 ohm.	
	Volts	**Volts**	**Volts**
TR5561/1	230	250 aside	6.3
	Type	**Transformer**	
SP1	6½ P.M.	5000 ohm.	
SW1	S.P.S.T. switch attached to R3		

RESISTORS

Ref. No.	Res.	Watts
R1	10 meg.	½ watt
R2	1 meg.	½ watt
R3	.5 meg.	pot
R4	.5 meg.	pot
R5	.25 meg.	½ watt
R6	15,000 ohm.	½ watt
R7	100,000 ohm.	½ watt
R8	47,000 ohm.	½ watt
R9	5,000 ohm	½ watt
R10	20,000 ohm.	½ watt
R11	10,000 ohm.	1 watt
R12	1,500 ohm.	5 watt w.w.
R14	1,500 ohm.	½ watt
R15	500 ohm.	½ watt
R16	300 ohm.	1 watt





SCHEMATIC DIAGRAM PACEMAKER MODEL 617 P.

VOLTAGE READINGS

Use	Tube	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
RF.	6SG7	OV	OV	OV	OV	OV	75V	6.3AC	128V
Conv.	6SA7	OV	OV	162V	75V	—2.5V	OV	6.3AC	OV
I.F.	6U7G	OV	OV	162V	75V	O	162V	6.3AC	4.3V
Det-AF.	6Q7GT	OV	OV	35V	OV	O	75V	6.3AC	O
Output	6V6GT	OV	OV	160V	162V	O	OV	6.3AC	7.7V
Rect.	6X5GT	OV	OV	230V AC	OV	230V AC	OV	6.3AC	225V

1. D.C. Voltage measurements are at 2,000 ohm per volt—A.C. Voltage measured at 1,000 ohm per volt.
2. Socket connections are shown as bottom views.
3. Measured valves are from socket pin to common negative.

RESISTANCE READINGS

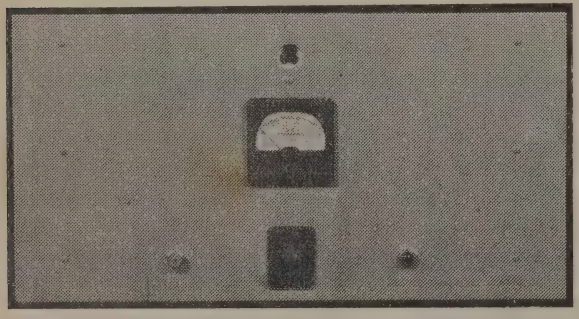
Use	Tube	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
RF.	6SG7	O	O	O	1.6 meg	O	30K	O	23K
Conv.	6SA7	O	O	20K	30K	20K	.25 ohm	O	1.6 meg
I.F.	6U7G	O	O	20K	30K	O	20K	O	1.5K
Det-AF.	6Q7GT	O	O	300K	1NF	500K	30K	O	O
Output	6V6GT	O	O	20K	20K	500K	500K	O	330 ohm
Rect.	6X5GT	O	O	480 ohm	1NF	480 ohm	1NF	O	20K

4. Nominal tolerance on component valve make possible a variation of ± 10% in voltage and resistance readings.
5. Volume control at maximum, no signal applied for voltage measurements.
6. Resistance readings in B+ circuits may vary widely according to the condition of filter capacitors.

The PHILIPS Experimenter

No. 25: CONSTRUCTION AND POWER SUPPLY CIRCUIT OF THE 50-WATT MODULATOR

In the September issue of the "Experimenter No. 23, we gave the circuit and a description of the speech equipment which we have designed for the Philips amateur transmitter. This month's issue shows photographs of the completed modulator and speech-amplifier unit and the circuit of the power supplies for it. There are two supplies, readers will remember, one for the screen grids and the other for the plates. This was done in order to use standard lines of trans-



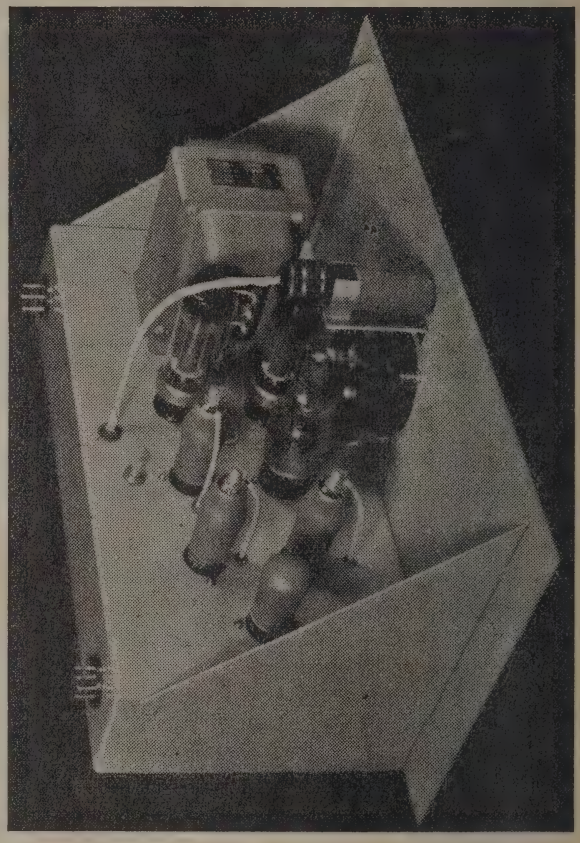
Illustrating the simple appearance of the front panel. The gain control is below the plate meter 0-250 ma.) and the input connector is at the left of the gain-control plate.

former throughout, and so to make the purchase of parts less expensive. It was also done in order to improve the regulation of both supplies and so to ensure that the modulators give their full rated power output.

It will be seen from the photographs that the power supplies have not been included on the same chassis as the circuit itself. This has been done because the transmitter has been designed as a whole and because doing so enables all the supplies of the transmitter to be placed on a single chassis. There will be four altogether: two for the modulator, one for the exciter, and one for the final amplifier. The V.F.O., it will be remembered, has its own power supply built in.

CONSTRUCTION OF THE MODULATOR

The modulator is built on a chassis 16 in. x 8 in., with a standard 19 in. rack panel attached by means of side brackets. The lay-out is clearly shown in the photograph. The two rows of valves are 2½ in. apart, and are equally spaced about the centre-line of the chassis. The EL34's can be seen next to the modulation transformer. The centre valve in the front row (nearest the panel) is the ECC32 phase inverter, while the other valve in the front row is the EF39, gain-controlled speech amplifier. At the extreme left-hand end of the chassis is the EB34 control rectifier. The valve directly behind the EF39 is the EF37 control amplifier, while the one behind the ECC32 is the EBC33 level-indicator valve. The EM34 indicator is mounted above the meter, which measures the EL34 stage's plate current. On the back of the chassis are two plugs. The one behind the modulation transformer is a four-pin one, of which only two pins are used. These terminate the secondary of the modula-



Top view of the modulator chassis. The lay-out is described in the text.

tion transformer, so that the unmodulated final H.T. voltage comes in via one of them and the modulated voltage leaves from the other. The plug at the other end of the chassis is used for the power supply leads, and is an octal, in which all eight pins are used. Two sets of filament leads account for four pins, the two H.T. supplies, with a common earth return, take three more, and the remaining one is for the modulator bias. The male plugs have been placed on the chassis so as to avoid the danger of having leads coming from the power supplies terminated in open plugs with live contacts. The danger referred to is not only to the unfortunate power supplies should the plugs come in contact with the chassis or other earthed object, but to the operator, who is, if anything, rather more important! We have not printed an under-chassis photograph or a working drawing for the chassis, since the wiring is simply straightforward audio work, and in the latter case because the lay-out is so simple as to allow builders to make their own drawings, if necessary.

If the photograph is carefully examined, it will be possible to pick out the two pre-set potentiometers.

The balancing potentiometer, in the grid circuit of one half of the ECC32, can just be seen between the EL34's partially obscured by the EBC33, behind which the setting potentiometer for the level-indicator circuit is clearly visible.

THE MODULATOR POWER SUPPLY

The accompanying diagram shows the circuit for the two power supplies needed for the modulator and speech amplifier. It will be seen that they are quite straightforward and embody no innovations of any sort. The upper supply is for the plates of the modulation and the voltage amplifier stages. It uses a standard transformer rated at 500 volts-a-side, 200 ma. A two-section filter is used, not so much because the filtering needed is particularly great, but in order to improve the regulation by making the input choke, L_4, a swinging choke. At light current drains, the latter has a fairly high inductance, so that the filter has the characteristics of a choke-input filter. At heavier drains, the swinging choke's inductance decreases, owing to partial saturation of the core material, so that the output voltage at the input to the filter rises and attempts to offset the decrease in output voltage due to the heavier current through the transformer and chokes. At full current output, the swinging choke has only a very small inductance, with the result that the output from the rectifier approaches that of a power supply with a condenser-input filter. The regulation is thus much better than that of an ordinary power supply.

The lower supply is for the screens of the EL34's, and is a simple 80 ma. supply with a condenser-input filter and two sections of filtering. Better filtering is needed for the screens than for the plates, because the screens are fed in parallel, and any hum voltage applied to them is not cancelled out in the modulation transformer as with the plate supply.

It is important that the screens should have a well-regulated power supply, but, since the current swing is so much less than in the plate circuit, there is no need to go to the trouble of having a specially designed supply. Good enough regulation is had by using an 80 ma. transformer and placing across the output of the supply a bleeder resistor which draws 25 ma. or so. The swing in output current is then from 30 ma. to 86 ma., a range of only 2.8 to 1, as against 11.2 to 1 for the screens themselves, as would take place if a bleeder were not used.

As was indicated previously, there is a precaution that must be taken if the screen and plate supplies are separate, as here. It is to see that plate and screen voltages are applied either simultaneously, or plate before screen. If the screen voltage comes first, the screen current will be excessive, and will damage the valve. The easiest way to look after this is to use

(Continued on page 40.)

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PUBLICATIONS RECEIVED

"Electronics Manual for Engineers," First Edition; by Vin Zeluff and John Markus. Publishers: McGraw-Hill Book Company, Inc.

Messrs. McGraw-Hill are the publishers of our well-known American contemporary, "Electronics," and will also be well known to our readers through their many exedllent text-books on radio and electronic subjects. The "Electronics Manual for Engineers" is a large volume of 879 pages, and consists of reprints of the most important papers and articles that have been published in "Electronics" over a period of several years.

The articles are grouped under a number of generic headings, which give some idea of the wide range of subject-matter presented. These sections are: I Antennas, II Audio, III Circuit Theory, IV, Components, V, D.C. Amplifiers, VI, Filters, VII Ionosphere, VIII Measurements, IX Microwaves, X Power Supplies, XI Production, XII Receivers, XIII Television, XIV Transmission Lines, XV Transmitters, and XVI Tubes.

When it is realized that the total of articles is 289, one can gain some idea of the scope of the book. As its authors point out in a short preface, monthly magazines are not exactly the most convenient form of reference material, especially after several years of the same publication have accumulated, and the object of collecting the articles in book form is to give engineers a ready reference source to a large number of papers, each of which can be considered important in its own field. The writer is fortunate enough to have read most of these articles in their original form, and welcomes the book as a means of saving many hours of searching for elusive titles, whose authors have been forgotten. Those who have not had ready access to the pages of "Electronics" over the last seven years or so, will find it a mine of new information, written in the main by acknowledged authorities in their own lines.

If there is a criticism that can be levelled against this excellent volume it is that some of the longer and more important articles appear to have been condensed considerably, but to some extent this can be forgiven, since the publishers must have fallen between the stools of printing all articles in full and of leaving out some that could otherwise have been included. As might be expected, the price of the book is high ($9.50 in the U.S.A.), but, then, so is the quantity and quality of the material presented, and engineers will find more than adequate recompense for their outlay in the wealth of information provided by the authors.

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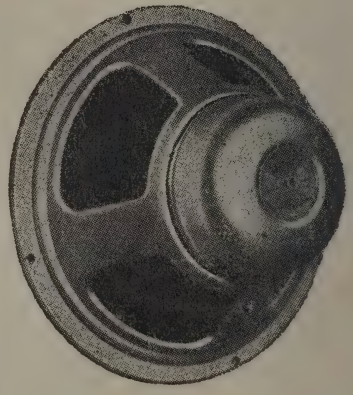

P.44

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"Physical Aspects of Colour," by Dr. P. J. Bouma. Publishers, Philips Industries, Eindhoven, the Netherlands.

The physiologist, the psychologist, the physicist, the illumination engineer, the chemist—each has studied the problem of colour perception from his own point of view and expressed the results in his own particular technical language.

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A strictly limited number of copies of this comprehensive book have been received, and may be obtained from Philips Technical Library, Box 1673, G.P.O., Wellington, at a cost of 25s.

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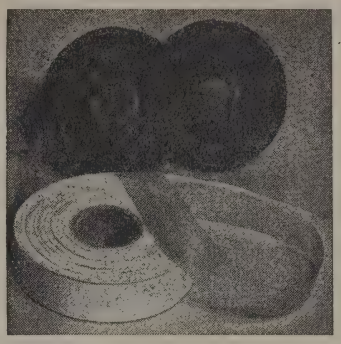

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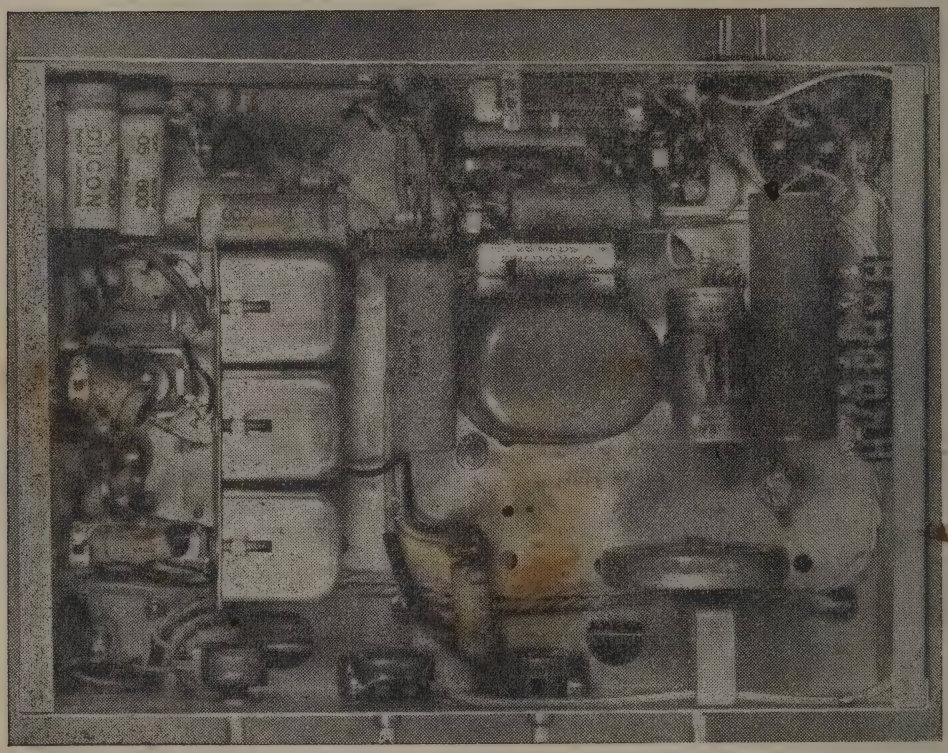


HEATER CIRCUITS

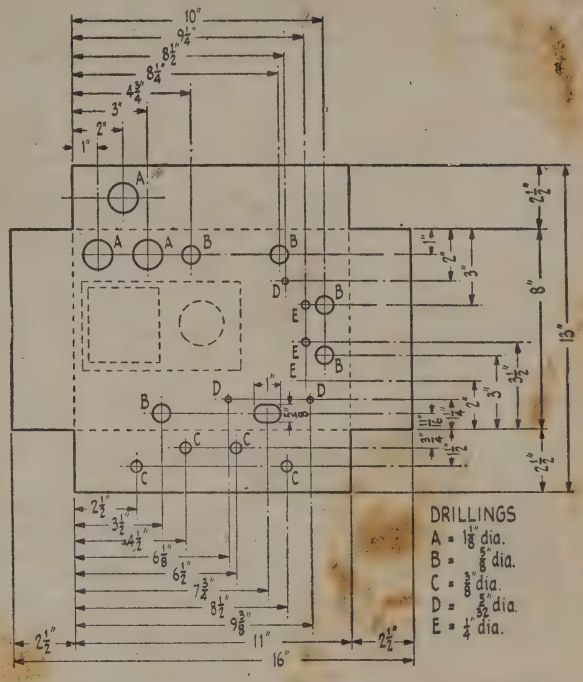
Since this set is designed for a supply of 12 volts D.C., it is clearly necessary to decide how the heaters should be grouped. We have not used 12-volt valves, since these are not generally available, so that we must put up with a series-parallel arrangement of the heaters. There is no difficulty about four of the valves, because each takes the same heater current of 0.3 amp., with the result that any two can be wired in series and connected across the 12-volt accumulator. The only valve that causes any concern is the 6V6, because its heater takes 0.45 amp. Thus, if it is wired in series with another of the valves, it will be necessary to shunt the heater of this valve with a resistance which draws 150 ma. at 6 volts, enabling the correct voltage to be applied to both the 6V6 and the valve whose heater is in series with it. The circuit shows that V_4, the 6AV6, has been placed in series with the 6V6, and that a 42-ohm resistor, R_{21}, has been shown across the 6AV6 heater. This resistor is made up by connecting a 50-ohm and a 250-ohm resistor in parallel. The watts dissipated in this resistor are 0.95, so that, to prevent too much heating, it is a good idea to use two 1-watt 100-ohm resistors in parallel rather than a 1-watt 50-ohm resistor.

The heaters of V_2 and V_3, the oscillator-mixer and I.F. amplifier valves, are connected in series across the 12-volt supply, so that we still have left the R.F. amplifier valve, V_1, which unfortunately has no remaining valve with which it can be grouped. There is an easy way out of the difficulty, however, because we have as yet made no provision for dial lights. The dial used in the prototype required two lamps, so that the obvious scheme was to use two 150 ma. lamps in parallel and connect the combination in series with the heater of V_1. All the valves are now catered for, and we are in the happy position of not having been forced to connect any of the valve heaters directly in parallel. Doing this is asking for trouble, for, if one heater of a series-parallel combination burns out, the one that was in parallel with it immediately receives an over-voltage, and is in danger of burning out, too. It should be remembered, however, that a set like this, where the dial lamps are an essential part of the circuit, will become inoperative should the dial lamps burn out or become loose in their sockets. It is essential, therefore, to see that a good type of lamp socket is used and that the lamps themselves are firmly in their sockets. If the set is being built for someone else, the owner should have it pointed out to him that if one of the dial lamps goes the whole set will be out of action, so that he can take the precaution of carrying spare dial lamps. It is, of course, necessary to see that the right kind

of lamp is used, as 0.3 amp. lamps will cause the R.F. amplifier valve to have more than the regulation 6 volts on its heater, and will themselves last only a short time.

CHASSIS AND CONSTRUCTION

The chassis used in constructing the prototype was a commercial one, put out by the manufacturer of the coils. Although the chassis is eminently suitable as far as valve lay-out is concerned, it was originally designed for full-sized valves, so that the holes for all but the 6V6 are too large. We got over this difficulty by blocking up the original holes with 16-gauge sheet aluminium in which holes of the correct size for miniature tubes had been bored. The chassis diagram herewith gives the correct dimensions and spacing for those who wish to make their own chassis or to have one specially made. The general arrangement of the set is quite well shown in the cover photograph of this issue. In this photo, the aluminium plates which block up the original holes can be seen, together with the self-tapping screws which mount them to the chassis. A useful dodge which helps considerably in eliminating instability of the R.F. amplifier stage is to use the front section of the gang for the aerial circuit, the centre section for the oscillator, and the back section for the mixer grid circuit. This gives quite a wide physical separation between the two circuits that are tuned to signal frequency—namely, the R.F. and mixer grid circuits, and we often wonder why more commercial sets do not use the same arrangemenment, which is a good one and much to be recommended. The R.F. valve is, of course, the one at the extreme left of the photograph. Next to it is the 6BE6 mixer-oscillator, and in the corner of the



chassis is the first I.F. transformer. Next to this, and directly behind the gang condenser is the 6BA6 I.F.

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amplifier valve, followed along the back of the chassis by the second I.F. transformer, the 6AV6 second detector, etc., and the 6V6 output valve. In case some readers should wonder whether it is considered necessary to have a metal 6V6, as shown in the photograph, we would like to say, "No." The one shown simply happened to be a metal one that was about in the laboratory when the photograph was taken, and a 6V6-G or 6V6-GT will do equally well. Next to the 6V6 is shown an empty valve socket. This is the one originally intended to take the rectifier valve, but, seeing that this set does not use one, advantage was taken of it to use it as the speaker socket. The male plug mounted on the back of the chassis is for connecting the battery leads. The idea of using a male socket instead of a normal female one is to prevent unintentional short-circuiting of the battery, as could occur if the male connector carried the voltage.

There is plenty of room on the chassis for the vibrator unit. This is mounted on rubber grommets so that vibration will not be directly transmitted to the chassis and also so that single-point earthing can be used. The ZC1 power supply has four leads issuing from it, two each for the 12-volt input and the 250-volt output. The black one is A —, the red one B +, the yellow one B —, and the remaining one is A +. **It is very important to note that the ZC1 power supply is arranged to have the battery connected in the above manner, so that if the positive terminal of the the battery of the car or boat is earthed, it will be necessary to reverse both the connections to the primary and to the secondary.**

To make the matter clearer, let us suppose that we wire the black lead to the chassis, in the normal way, but have to reverse the battery connections because the car's system has the positive battery terminal earthed, then the set will not work, because the polarity of the H.T. voltage will have been reversed by so doing. Thus, if the set is to be used with a positively earthed system, the yellow lead will

Beacon Technical Topics No. 18

DISTRIBUTION OF LOSSES IN POWER TRANSFORMERS

The purpose of this topic is to show how the total power-loss in a small power transformer is made up of three individual losses and the way these losses can be varied by the choice of material and operating conditions.

The total power-loss, *in small transformers,* can be considered as the sum of core and copper losses. The core loss is subdivided into hysteresis and eddy components.

Dealing now with the control of these losses: It can be shown that the eddy current loss is proportional to the square of the flux density. For practical purposes the hysteresis loss is also considered proportional to the square of the flux density. This is not necessarily correct, but for the grade of silicon steel in common use the error is not very great.

The cores losses also depend on the type of steel used. The hysteresis loss varies with the shape of the B-H loop, while eddy current loss depends on the thickness, resistivity, and insulating surface of the laminations. It follows, then, that we have more factors with which to control the eddy current loss than we have for controlling hysteresis loss. With the grade and thickness of silicon steel commercially available, the eddy current loss is usually about one-third of the total core losses.

Considering now the copper loss: Since the windings are invariably of soft copper, the resistivity is fixed, and the copper loss for a given winding can be considered proportional to the square of the current density.

It is often desirable to have the copper and core losses approximately equal, especially when considering a variable load. Maximum efficiency occurs when the two losses are equal, and this can be arranged at the particular loading required.

BEACON power transformers have a total power-loss determined either by the temperature rise or efficiency required. This loss is very often evenly divided between the copper and iron, depending on the transformer application. Of the total core losses, the hysteresis usually comprises two-thirds, the remainder being due to eddy currents. The total copper loss is normally divided evenly between the the primary and secondary windings, thereby making most efficient use of the winding space.

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be B + and the red one B —. As long as this is remembered, all will be well, but, if not, the valves will get a negative H.T. voltage on their plates and screen, and will not function at all. Also, it is not possible to connect the other A lead from the unit to earth and feed A — in through the black lead without making a circuit change inside the unit itself. By far the simplest way of coping with the situation if the positive battery terminal is earthed is to reverse the primary and secondary connections, as indicated.

The construction under the chassis can be readily seen in the large underneath photograph. The shielded coils are mounted on a bracket underneath the condenser gang. This places the lugs on the coils in a very convenient position for wiring. Do not forget to make the front coil the aerial, the centre one the oscillator, and the back one the R.F., so that the recommended gang arrangement can be followed without crossing over wires under the chassis, thereby defeating the purpose of the scheme. The tuning spinner can be seen in the under-chassis view, with the volume control potentiometer next to it, followed by the tone control and the on/off switch. Almost in the centre of the chassis is the smoothing choke. Not a great deal of smoothing is needed, and a ZC1 choke is a cheap and effective component to use here. If desired, however, any 50 or 60 ma. smoothing choke can be used in this position.

It will be seen that no shield partitions have been used across either the R.F. or I.F. valve sockets. The set was found to be completely stable without them. The padder condenser can be seen opposite the junction between the two back coils and between the R.F. and mixer sockets. Liberal use has been made of insulating strip for mounting solder lugs, used as tie-points. It should be remembered that a set of this nature will be subjected to more vibration than the ordinary set, so that everything should be firmly tied down.

The alignment of the set is similar to that of any other superheterodyne, so that there should be no need to go into details here. As we said before, there is nothing difficult about the construction of this set, and builders will find it as easy to get going as any other broadcast set with a similar valve line-up.

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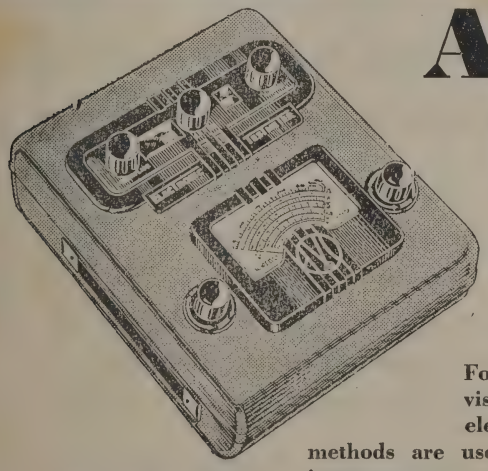

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THE NEW ZEALAND ELECTRONICS INSTITUTE (INC.) NEWSLETTER

On Tuesday, 22nd August, the Christchurch branch of the New Zealand Electronics Institute was addressed by Dr. A. G. Bogle, D.Phil., B.E., Chief Electrical Engineer of the Dominion Physical Laboratory. In his address, Dr. Bogle dealt with a number of the major projects which had received attention by the Electronics Section of the D.P.L. during recent months. In addition, he dealt with the "Electronic Speed Cop," which had been developed by the Radar Section.

RESISTANCE STRAIN GAUGE

Dr. Bogle explained that this is an electronic device for determining the relative strain resulting at any point in a structure during the application of a load. A 4000 c/sec. oscillator is applied to a Bridge circuit, one arm of which includes the strain gauge. This consists of a mat of wires embedded in fabric, the whole being glued to the structure at the point where observations are required. Distortion of the gauge by strain changes its resistance, so unbalancing the bridge, thereby modulating the initial 4000 c/sec. at an amplitude and frequency proportional to the strain in the member. This modulation is fed to an amplifier with a gain of 120 db. and a bandwidth of 400 c/sec. The limit of strain frequency that can be observed is thus 200 c/sec. The output of the amplifier is applied to a cathode ray tube. The complete gauge comprises six such units, coupled to a common display unit in which are mounted the six cathode ray tubes and a camera with a motor-driven film, thereby permitting observations to be made simultaneously at six points in the structure.

"ELECTRONIC SPEED COP"

This device, said Dr. Bogle, depends for its operation on the "Doppler Effect," not on any form of pulse technique, and cannot strictly be termed a radar device, since it does not determine position. The apparatus obtains its indication by measuring the difference in frequency between the transmitted and reflected signals. As the change of frequency on reflection is directly proportional to both the car velocity and the transmitter, it is obvious that this frequency must be as high as possible. In actual fact, the transmitters use a "lighthouse" tube oscillating at 3000 mc/sec. The receiver is a superheterodyne using a Klystron oscillator operating at 3030 mc/sec. Automatic frequency control ensures that the 30 mc/sec. frequency difference is maintained constant. These frequencies, together with the received frequency, are fed to a crystal mixer, the output of which is fed to 30 mc/sec. I.F. amplifier with a bandwidth of 2 mc/sec. The second detector thus gives an output of a frequency equal to the difference between the transmitted and received frequencies. This output is arranged to give a reading on a meter directly calibrated in miles/hour.

ULTRA-VIOLET INTEGRATOR

Continuing, the speaker said that three of these units have been constructed and will eventually be placed in service in various parts of the Dominion. The object is to measure the total ultra-violet radiation at these points over a given period in an attempt to determine what part ultra-violet radiation has in certain biological phenomena. Special photo-tubes sensitive to ultra-violet light were secured for the units. The photo-tube is installed in a sealed perspex container. The associated circuit includes a "charging condenser" and a cold cathode discharge tube. The frequency of operation of this circuit is governed by the intensity of ultra-violet light reaching the photo tube. The output of this section is applied to a diode, the output of which is coupled to the grid of a 6V6 in the plate circuit of which is the "counter coil." The action of this part of the equipment is additive, so that a measure of the total ultra-violet radiation is recorded.

QUARTZ CRYSTAL CLOCK

The construction of this instrument, said the speaker, was the result of a request by the Dominion Observatory for a clock with an accuracy of better than two seconds a month. A 100 kc/sec. crystal-controlled oscillator is fed through four frequency dividing stages using blocking oscillator followed by a multivibrator stage. The output is in the form of a 50 c/sec. square wave. This is filtered and fed to a resonant circuit, thereby producing a 50 c/sec. A.C. output to run an ordinary electric clock motor. The electronic apparatus is designed with a view to battery operation, but at present is supplied from the mains. The 50 c/sec. is arranged to beat with the A.C. mains to operate a Neon indicator, so that any instability in the operation of the dividing circuits becomes quickly apparent.

RADIOGRAPHY TIMER

After reference to an experimental "shock therapy" apparatus, Dr. Bogle concluded with details of a radiograph timer. In mass radiograph, it is very desirable for a rapid and accurate determination of correct exposure time to be made. In this device, a projection of the total light reaching the X-ray plate is focused on to a multiplier photo-tube. The output

(Continued on page 48.)

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TUBE DATA: A COMPLETE LIST OF CURRENT MINIATURE VALVES

We are indebted to Amalgamated Wireless Valve Co. Pty., Ltd., for this up-to-date list of all miniature valves produced by American and British manufacturers. The list, of course, includes types made by A.W.V. themselves.

B7G RECTIFIERS

Type.	V (Heater)	MA		Sim. Types.
1B48	Cold Cath.		—	—
IZ2	1.5	300	H.W.	—
2B25	1.4	100	H.W.	—
6X4	6.3	600	F.W.	6X5-GT, U78
35W4	35	150	H.W.	35Z5-GT
45Z3	45	75	H.W.	—
117Z3	117	40	H.W.	117Z4-GT
1654	1.4	50	H.W.	—
5517	Cold Cath.		H.W.	—
EY91	6.3	420	H.W.	—
HR1	0.65	55	H.W.	—
HR2	4	500	H.W.	—
HR3	4	500	H.W.	—
HR4	4	500	H.W.	—
R10	4	500	H.W.	—

B7G DIODES

Type.	V (Heater)	MA	Diodes	Sim. Types.
1A3	1.4	150	1	1D13
1D13	1.4	150	1	1A3
6AL5	6.3	300	2	6H6-GT
6AN6	6.3	200	4	—
6D2	6.3	300	2	6AL5
12AL5	12.6	150	2	12H6-GT
5722	4.8	1,500	1	—
5726	6.3	300	2	RUGGED 6AL5
9006	6.3	150	1	—
D77	6.3	300	2	6AL5
DA90	1.4	150	1	1A3
DD6	6.3	300	2	6AL5
EB91	6.3	300	2	6AL5

B7G TRIODES

Type.	V (Heater)	MA	GM	Sim. Types
6AB4	6.3	150	5,500	—
6C4	6.3	150	2,200	6J5-GT
6J4	6.3	400	12,000	—
6N4	6.3	200	6,000	—
5610	6.3	150	4,000	—
9002	6.3	150	2,200	—
EC91	6.3	300	8,500	—
L77	6.3	150	2,200	6C4

B7G TWIN TRIODES

Type.	V (Heater)	MA	GM	Sim. Types
3A5	1.4/2.8	220/110	1,800	—
6J6	6.3	450	5,300	—
19J6	18.9	150	5,300	—
DCC90	1.4/2.8	220/110	1,800	3A5
ECC91	6.3	450	5,300	6J6

B7G DIODE TRIODES

Type.	V (Heater)	MA	Diodes	Sim. Types.
6AQ6	6.3	150	2	6T7-G
6AT6	6.3	300	2	6Q7-GT
6AV6	6.3	300	2	6SQ7-GT
6BF6	6.3	300	2	6SR7-GT
12AT6	12.6	150	2	12Q7-GT
12AV6	12.6	150	2	12SQ7-GT
12BF6	12.6	150	2	12SR7-GT
26C6	26.5	70	2	—
EAC91	6.3	300	1	—

B7G DIODE PENTODES

Type.	V (Heater)	MA	GM	Sim. Types
1FD9	1.4	50	625	1S5
1S5	1.4	50	625	—
1U5	1.4	50	625	1S5
DAF91	1.4	50	625	1S5
ZD17	1.4	50	625	1S5

B7G R.F. PENTODES (SHARP CUT-OFF)

Type.	V (Heater)	MA	GM	Sim. Types
1F2	1.4	50	1,025	—
1L4	1.4	50	1,025	1N5-GT
1U4	1.4	50	900	1N5-GT
6AH6	6.3	450	9,000	6AC7
6AJ5	6.3	175	2,750	—
6AK5	6.3	175	5,100	—
6AM6	6.3	300	7,500	Z77, EF91
6AS6	6.3	175	3,200	—
6AU6	6.3	300	5,200	6SH7-GT
6BH6	6.3	150	4,600	—
6F12	6.3	300	7,500	EF91, Z77, 6AM6
6F33	6.3	350	4,350	—
8D3	6.3	300	7,500	EF91, Z77, 6AM6
12AU6	12.6	150	5,200	12SH7-GT
12AW6	12.6	150	5,000	—
5591	6.3	150	5,100	—
5654	6.3	175	5,000	RUGGED 6AK5
5725	6.3	175	3,200	RUGGED 6AS6
9001	6.3	150	1,400	—
DF92	1.4	50	—	1U4
EF91	6.3	300	7,650	6AM6, Z77
Z77	6.3	300	7,500	6AM6, EF91

B7G R.F. PENTODES (REMOTE CUT-OFF)

Type.	V (Heater)	MA	GM	Sim. Types
1F3	1.4	50	900	1T4
1T4	1.4	50	900	1P5-GT
6AG5	6.3	300	5,000	6SH7
6BA6	6.3	300	4,400	6SG7-GT
6BD6	6.3	300	2,000	6SK7-GT
6BJ6	6.3	150	3,800	6SS7-GT
9D6	6.3	200	2,500	EF92
12BA6	12.6	150	4,400	12SG7-GT
12BD6	12.6	150	2,000	12SK7-GT
26A6	26.5	70	4,000	—
5590	6.3	150	2,000	—
9003	6.3	150	1,800	—
DF91	1.4	50	900	1T4
EF92	6.3	200	2,500	W7 7
W17	1.4	50	900	1T4
W77	6.3	200	2,500	EF92

B7G CONVERTERS

Type.	V (Heater)	MA	GM	Sim. Types
1C1	1.4	50	300	1R5
1L6	1.4	50	300	—
1R5	1.4	50	300	1A7-GT
6BE6	6.3	300	475	6SA7-GT

12BE6	12.6	150	475	12SA7-GT
26D6	26.5	70	475	—
DK91	1.4	50	300	1R5
X17	1.4	50	300	1R5

B7G OUTPUT

Type.	V (Heater)	MA	GM	Sim. Types
1P10	1.4/2.8	100/50	1,575	3S4
1S4	1.4	50	1,575	1Q5-GT
2E30	6.0	650	3,700	—
3A4	1.4/2.8	200/100	1,900	—
3B4	1.25/2.5	200/100	1,700	—
3Q4	1.4/2.8	100/50	2,150	3Q5-GT
3S4	1.4/2.8	100/50	1,575	3Q5-GT
3V4	1.4/2.8	100/50	2,150	3Q5-GT
6AJ5	6.3	175	2,750	—
6AK6	6.3	150	2,300	—
6AM5	6.3	200	2,600	EL91
6AN5	6.3	—	8,000	6AG7
6AQ5	6.3	450	4,100	6V6-GT
6AR5	6.3	400	2,400	6K6-GT
6AS5	6.3	800	5,600	7A5
35B5	35	150	5,800	35L6-GT
35C5	35	150	5,800	35L6-GT
50B5	50	150	7,500	50L6-GT
50C5	50	150	7,500	50L6-GT
5618	3/6	460/230	3,600	—
DL92	1.4/2.8	100/50	1,580	3S4
DL93	1.4/2.8	200/100	1,900	3A4
DL94	1.4/2.8	100/50	2,150	3Q4
DL95	1.4/2.8	100/50	2,150	3V4
EL91	6.3	200	2,600	6AM5
N17	1.4/2.8	100/50	1,500	3S4

B7G THYRATRONS

Type.	V (Heater)	MA	Sim. Types
2C4	2.5	650	—
2D21	6.3	600	2050

6D4	6.3	250	—	—
5662	6.3	150	—	—
5663	6.3	150	—	—
5696	6.3	150	—	—

B7G REGULATORS (COLD CATH.)

Type.	V (Heater)	MA	Sim. Types
0A2	—	—	0D3
0A5	—	—	—
0B2	—	—	0C3
5651	—	—	—
QS70/20	—	—	—
QS95/10	—	—	—
QS150/15	—	—	—
5823	—	—	0A4-G

B7G NEON INDICATOR

Type.	V (Heater)	MA	Sim. Types
XL600	—	—	—

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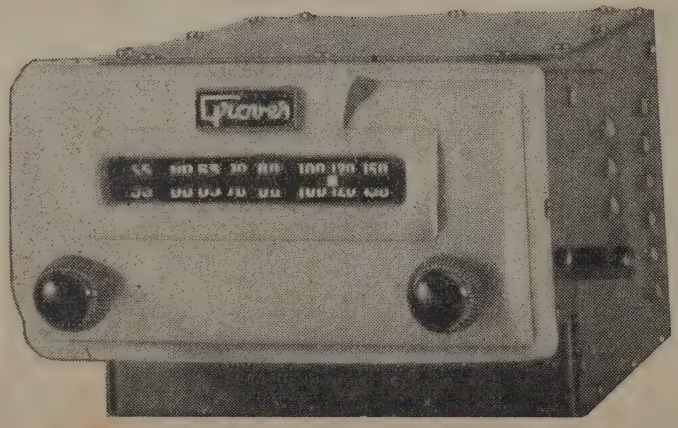

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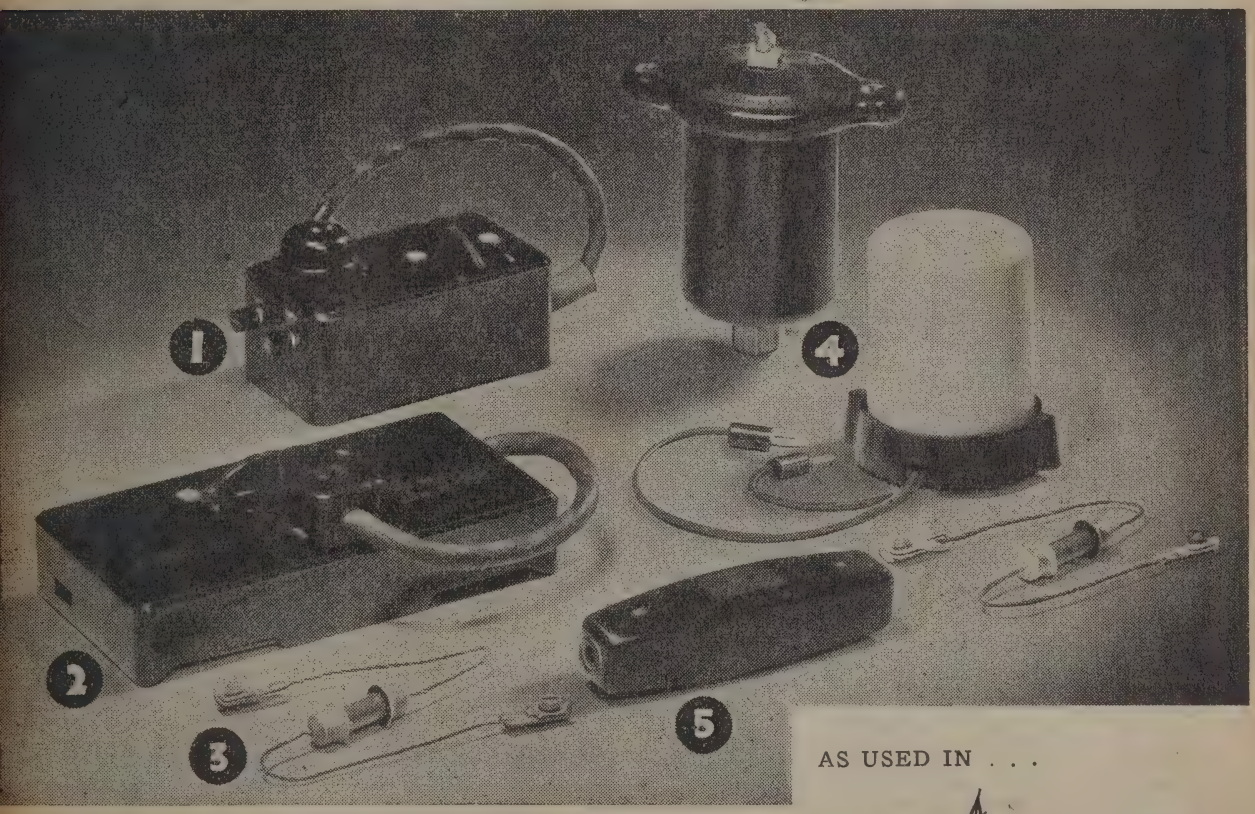

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A Microwave Vehicle Speed Indicator

By Dr. A. G. BOGLE

Readers will be aware, through the daily Press, that an equipment has been developed by the Dominion Physical Laboratory of the Department of Scientific and Industrial Research to enable officers of the Transport Department to determine the speed of road vehicles. This equipment has been referred to as the "Electronic Speed Cop," but little detailed information of its mode of operation has been given.

PRINCIPLE OF OPERATION

The basic principle of the speed determination is what is called the Doppler effect, which will probably be more familiar in relation to sound waves than to radio waves. Most people will have noticed that when they have been in a train passing a crossing bell, the pitch of the bell dropped suddenly as they passed it. The effect appears because we intercept the sound pressure waves from the bell more frequently than normal when we are moving towards it and less frequently than normal when we are moving away from it. The velocity of the movement is effectively added to, and subsequently subtracted from, the normal speed of sound (1100 ft./sec. = 750 m.p.h.).

The same effect occurs with radio waves. If a car carrying a radio transmitter is approaching a receiver, the frequency received is a little higher than normal. But in this case the speed of the car is so very much smaller than the velocity of the radio waves (186,000 miles/second) that the **proportional** difference in frequency is minute. However, the actual difference can be made large enough to detect by using a high enough transmitted frequency.

Obviously, it is necessary to obtain the speed information without the need for special equipment in every car. So a beam of radio waves is directed at the car under observation, and the frequency of the reflected waves is compared with that of the outgoing waves. Then the difference is directly proportional to the speed of the car. The system resembles radar in that super-high frequencies and a beam aerial are used, but is strictly not radar, since it uses continuous waves and does not actually determine the position of the target.

If f = the transmitted frequency in cycles per second, V = velocity of target, and C = velocity of radio waves, the difference, df, between the transmitted and received signals is approximately 2 fV/C.

If V is expressed in m.p.h. and f in terms of wavelength L in centimetres, df = 89.4V./L.

This shows that, for ordinary vehicle speeds, a very short wavelength must be used to get an observable frequency change. A wavelength of 10 cm. is suitable from the point of view of availability of components, and gives a frequency difference of 9 c/s. per m.p.h., which can be observed practicably.

TECHNICAL DETAILS

The scheme of operation is best understood by reference to Fig. 1, which shows the various components in block form.

(1) Transmitter:

C.W. oscillators on this wavelength are available only with low power. The alternatives are triodes and klystrons—the magnetrons available in New Zealand are all of the pulse type, and are not suitable for C.W. operation.

A lighthouse triode, type GL446, was chosen. When used in a re-entrant cavity circuit, it delivers some 25 mW. at about 10 cm. wavelength (300 mc/s.). The power is coupled by a short length of polythene cable to a dipole situated at the focus of an 18-inch diameter paraboloid dish, forming an aerial with beamwidth approximately 20 degrees (see Fig. 2).

(2) Receiver:

The basic problem of reception is to raise the best frequency signal to a sufficient level for operating a frequency meter. Simple crystal detection and audio amplification was not found to give adequate sensitivity, so a superheterodyne receiver was developed.

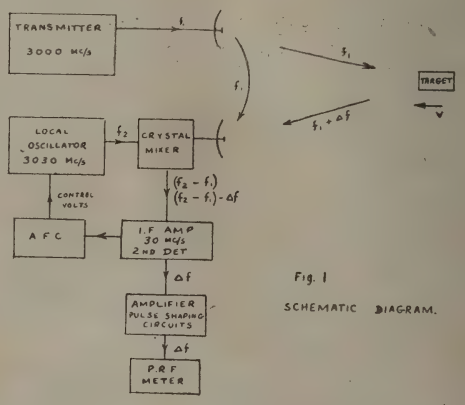

Fig. 1
SCHEMATIC DIAGRAM.

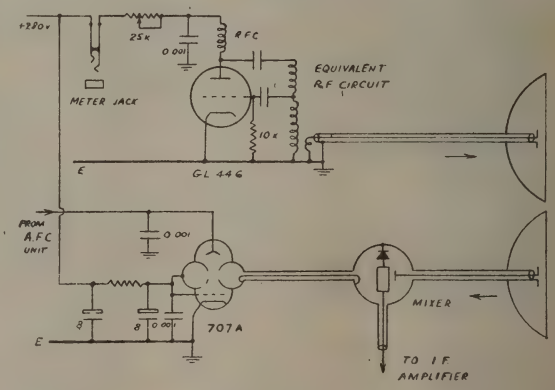

Fig 2
R F UNIT

A local oscillator valve (Klystron type 707A) generates a signal at 3030 mc/s., which is mixed with the signal collected by the receiving dish aerial—a second 18-inch paraboloid (see Fig. 2).

The receiving aerial signal will contain two components, one arriving direct from the transmitting aerial at 3000 mc/s. and the other being the reflected signal at $(3000 + 8.94V/10^6)$ mc/s. These three frequencies are then fed to a crystal (type 1N23A)

mixer of the type commonly used in radar receivers.

The output of the mixer comprises sums and differences of all three input frequencies; however, the only components of interest are (3030 — 3000) mc/s. and (3030 — 3000 — 8.94V/10^6) mc/s., since these are the only two which will pass through the I.F. amplifier whose centre frequency is 30 mc/s. and bandwidth is 2 mc/s. Thus the two components of 30 mc/s. and (30 — 8.94V)/10^6 mc/s. are amplified and passed to the second detector, whose output is then an audio signal of the difference frequency 8.94V c/s. The gain of the amplifier is about 80 db.

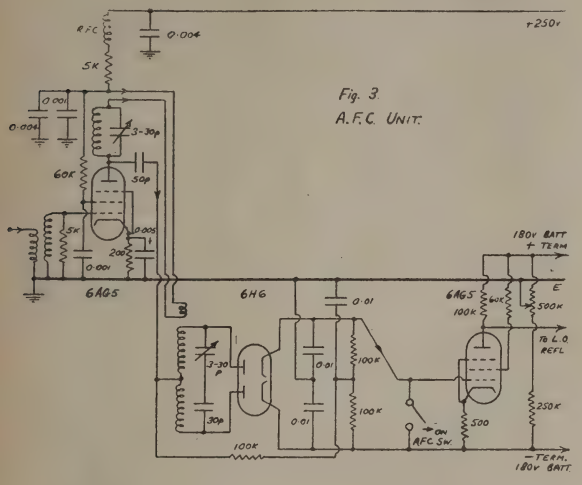

Fig. 3. A.F.C. Unit.

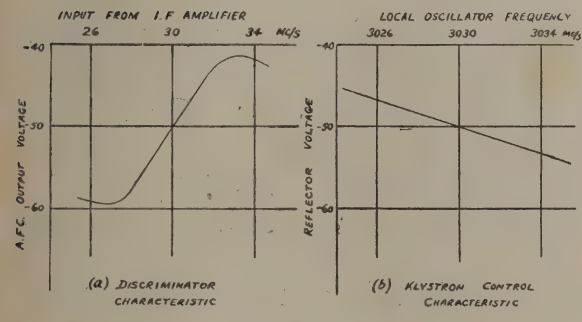

Fig. 4.

(3) Automatic Frequency Control:

Both transmitter and local oscillator are subject to frequency drifts caused by thermal and ageing effects, and, since the drifts are not equal, or even necessarily in the same direction, automatic control is necessary to maintain the difference within the limits of (30 ± 1) mc/s. A portion of the output of the I.F. amplifier is fed to a discriminator circuit (see Fig. 3). This circuit has the frequency characteristic shown in Fig. 4. Thus, if, for instance, the local oscillator frequency tends to rise, this causes a fall in the negative voltage applied to the reflector of the klystron, and so lowers its frequency, neutralizing the tendency to go off tune. Similar action takes place if the change of I.F. is caused by drift in the transmitter frequency, the local oscillator being kept always within ± 1 mc/s. of the transmitter.

(4) Audio Frequency Meter (see Fig. 5):

The output from the second detector is amplified in V1, clipped in V2a, inverted in V2b, inductively differentiated, and again clipped in V3a to produce negative going trigger pulses of the same frequency as the audio beat note. These pulses are used to trigger a single-shot multivibrator (V3b and V4); each time it is fired current flows through the valve V6 and the meter at a fixed level and for a preset

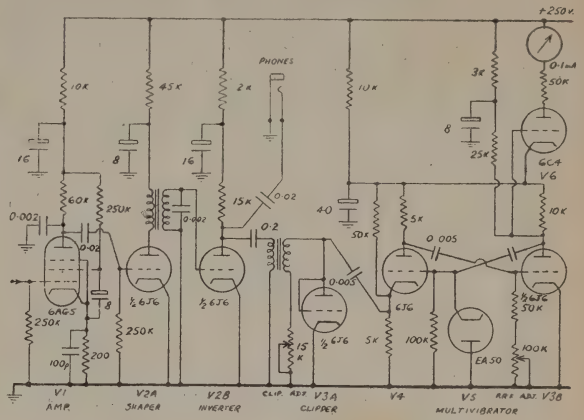

Fig. 5. Frequency Meter Circuit.

period, which is shorter than the shortest interpulse period expected. Thus the mean current through the meter, made up of these pulses of current, depends only on the frequency of the pulses—that is, on the frequency of the beat note. This circuit has been found to give a scale which is approximately linear from 0 to 60 m.p.h. (0 — 540 c/s.), with an error not exceeding 2 m.p.h.

Calibration is performed with a good quality beat frequency oscillator.

(5) Power Supply System:

A 6-volt 120-amp-hr. accumulator is used to supply all the filaments except the transmitter and local oscillator, a total drain of 5 amp.

A 12-volt 60 amp-hr. accumulator drives a pair of motor generators (6-amp.), whose output is 275 volts high-tension supply. This battery also feeds the transmitter and local oscillator filaments through a carbon-pile regulator.

Dry batteries provide 180 volt negative supply for the local oscillator reflector.

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The *Radio and Electronics* Abstract Service

AUDIO EQUIPMENT AND DESIGN:

High-quality Amplifier. A new version of the popular "Williamson" audio amplifier, incorporating slight modifications. Suggested lay-out of equipment and details of precautions to be taken in assembly. Loop gain and phase-shift characteristics of amplifier illustrated. Details of output transformer, described as the most critical component in the amplifier. Winding data for this transformer given. Particulars of a pre-amplifier for use with pick-ups and microphones of low output to be given in a subsequent article.

—Wireless World (Eng.), August, 1949, p. 282.

ANTENNAE AND TRANSMISSION LINES:

Standing waves and impedance circle diagrams. Graphical approach to transmission line theory. As an alternative to the algebraic consideration of standing waves on feeders and the associated impedance relationship, a method is adopted commencing with the idea of a pure travelling wave and the laws of superposition. The method used is fully described.

—Wireless Engineer (Eng.), July, 1949, p. 231.

Build your own TV tower. Description of method of constructing triangular antenna mast up to 50 feet in height, using half-inch thin wall conduit. Brazing is necessary in final assembly.—Radio News (U.S.A.), July, 1949, p. 55.

CIRCUITS AND CIRCUIT ELEMENTS:

Electronic Circuitry. (1) Electronic counters. Proceeding from scale-of-two counter, the writer discusses development of ring counters by reference to operation of ring-of-three counting circuit and its operation. (2) Extinguishing thyratons. Two methods described: one breaks H.T. supply temporarily by a switch, the other employs a switch to momentarily short-circuit to the negative H.T. line a condenser-resistance combination in the anode circuit of the thyraton. Time constant of C.R. combination is suitably chosen.

—Wireless World (Eng.), July, 1949, p. 260.

Electronic Circuitry. Design of electronic counter of any scaling factor, beginning with an appropriate chain of scale-of-two counters.—Wireless World (Eng.), August, 1949, p. 298.

"Q"—How many kinds are there? A detailed description of the meaning of Q. Discussion of principle of operation of Q-meters and methods of measuring the factor.

—Wireless World (Eng.), July, 1949, p. 267.

Miller Effect. Step-by-step resolution of some of its paradoxes. A clear explanation of theory involved.

—Wireless World (Eng.), August, 1949, p. 307.

Shock-impulsed Spiral Time Base. A new method of producing a spiral trace on C.R.T. Damped oscillatory voltage produced by shock-exciting an oscillatory circuit, is applied to an R-C phase-splitting circuit of the type used to produce a circular time base. Two trains of synchronized damped oscillations, 90 degrees out of phase, are formed and combine to give exponential spiral.

—Wireless Engineer (Eng.), July, 1949, p. 242.

A High-voltage Ring Modulator. "Phase conscious rectification" is necessary in certain cases—for instance, in the phase-control circuit of the "Synchrodyne" receiver. Two voltages are present, a reference and a signal voltage; the latter is derived in the first place from the same source. The amplitude of the signal voltage is modulated, and varies about zero. The reference voltage is of constant amplitude. Process of modulation is effected by the reference voltage and a ring-modulator is one of the most satisfactory types. The circuit developed makes use of large amounts of bias in the modulator arms to improve the rectifier characteristics and modulator efficiency. It is claimed that in using diodes the biased ring-modulator gives a satisfactory degree of precision as a phase-conscious rectifier, for use at voltages sufficiently high for the output to be applied directly to an output stage.

—Electronic Engineering (Eng.), July, 1949, p. 239.

Voltage Stabilizers: Part 3. Stabilizers employing thermionic valves. Circuits and operating details of various stabilizers for different output voltages. Circuits also given for stabilizers using Barretter Tubes and Metrosils.

—Electronic Engineering (Eng.), July, 1949, p. 243.

FREQUENCY MODULATION:

Diversity F.M. Transmission. As a challenge to contention that when wide coverage is required, calling for several transmitters, A.M. system with spaced carriers is preferable to F.M., an English company demonstrated that an F.M. system using three transmitters can be operated successfully to give desired coverage. Details of arrangement of transmitters, one master and two satellite unattended stations, and other technical aspects.—Wireless World (Eng.), July, 1949, p. 246.

MICROWAVE TECHNIQUES:

Earther-grid Power Amplifiers (concluding article). V.H.F. sound and vision transmitters. Methods of neutralizing illustrated and power gain discussed. Coaxial-line power amplifiers dealt with fully.

—Wireless Engineer (Eng.), July, 1949, p. 235.

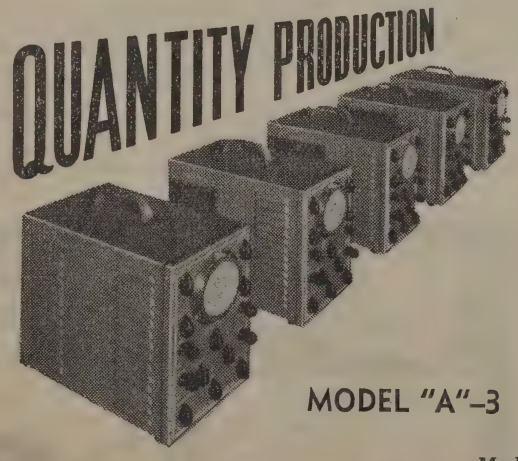
The Electromagnetic Horn: Part 1. Theory and practice, primary consideration being given to the electromagnetic horn as a radiator of energy.

—Electronic Engineering (Eng.), July, 1949, p. 255.

Electromagnetic waves in wave-guides, Part I. General theoretical principles. Rectangular wave-guides. Summary of methods for solving basic Maxwellian equations. Theory of propagation of electromagnetic waves in wave-guides, based directly upon fundamental equations of Maxwell theory.

Reducing heater hum in high-gain amplifiers. Circuit and method of reducing hum. The hum voltage is balanced out by injection into the amplifier valve of an appropriate proportion of heater voltage in anti-phase to the hum.

—Wireless World (Eng.), October, 1948, p. 360.



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MEASUREMENTS AND TEST GEAR:

Audio Signal Generator (Part 1 of article). Circuit and details of an audio oscillator covering 20 to 20,000 c/s. Basically the unit consists of two-valve resistance-capacitance oscillator, with cathode-follower output stage. Attenuator stages, a phase-inverter plus second output stage, and a squarer section incorporated for increased usefulness of oscillator in various types of measurement.—**Wireless World (Eng.), August, 1949, p. 294.**

Accurate Frequency Measurement. Proposed method for use up to 12,000 m/cs. Description whereby frequency difference between unknown source and a known crystal-checked harmonic of a relatively low-frequency tuned reference oscillator is measured. Unit consists of reference oscillator (300-600 m/cs.), a 4 m/cs. calibrator, 100 k/cs. crystal and multiplier), first mixer, second mixer, I.F. amplifier and oscillator (40-80 m/cs.), magic-eye indicator amplifier, and an audio frequency amplifier. Estimated that with careful design the overall error at 5 m/cs. may be 4 or 5 parts in 106.

—Wireless Engineer (Eng.), July, 1949, p. 218.

Measurement of Quality in Audio Reproduction. From a statement that investigations into listeners' preferences indicate that frequency range is only one of the important factors in reproduction of sound, the article deals with the other factors involved and their evaluation. General techniques of audio measurement described. Types of input and output signals and equipment used in testing various units of audio system summarized in tabular form. Second table gives types of test signal used in carrying out response and distortion tests.

—Radio News (Radio-Electronic Eng. Ed. U.S.A.), July, 1949, p. 3.

High-ratio Multivibrator Frequency Divider. Circuit of a divider capable of giving stable frequency division as high as 300 to 1. Possible to synchronize two widely-separated frequencies. Two-valve (each dual-triodes) multivibrator circuit employed, but modified so that feedback condenser is replaced by a tuned circuit followed by a two-stage clipper. When synchronizing voltage of frequency near to an integral multiple of tuned circuit is applied to input, the multivibrator adjusts itself to an exact subharmonic of the input. One application of the circuit is its use to provide a precise low-frequency generator.

—Radio News (Radio-Electronic Eng. Ed. U.S.A.), July, 1949, p. 7.

Electromechanical Phase Indicator. An indicator useful up to 400 c/s, for high impedance, low potential sources. Unit consists fundamentally of a high-speed relay. One input phase drives the coil of the relay and the contacts form a synchronous mechanical rectifier for the other phases. Zero centre D.C. microammeter constitutes rectifier load and is calibrated directly in phase-shift.

—Radio News (Radio-Electronic, Eng. Ed. U.S.A.), July, 1949, p. 14.

A New Visual Null Indicator. Circuit of a null indicator using a one-valve pentode amplifier for increased sensitivity. For wide application, two alternative impedances are provided. One is a high impedance and the other a low impedance with input transformer.—**Electronic Engineering (Eng.), July, 1949, p. 248**

Projective Three-dimensional Displays: Part 1. Problems involved in devising a useful three-dimensional display on C.R.T.. A practical circuit given. Photographs of displays on C.R.T. of secondary emission "valley" in characteristic surface of a tetrode and three elevations of surface $y = f(x, z)$.

—Electronic Engineering (Eng.), July, 1949, p. 249.

TELEVISION:

Transitron Sync Separator. Details of a one-valve transitron circuit operated under specific bias conditions and designed to give good interlacing.

—Wireless World (Eng.), July, 1949, p. 247.

Indoor Television Aerial. Brief review of small television antennae for indoor mounting in strong-signal areas. Description of recommended type of antenna based upon simple inductively loaded dipole. Constructional details.

—Wireless World (Eng.), July, 1949, p. 255.

Constant Voltage Sources for TV Receivers. Basic types of line-voltage fluctuations discussed, and the effects upon TV receivers. Use of constant-voltage transformer explained.

—Service (U.S.A.), June, 1949, p. 16.

TV and front ends. R.F. oscillator and mixer. Discussion of problems in design and U.S. manufacturers' methods of meeting such problems. Discusses also the means for measuring performance, and tuning methods. Gives an indication of likely future developments.

—Electronics (U.S.A.), September, 1948, p. 76.

TRANSMITTERS:

10-Metre Mobile Transmitter. Circuit and design of equipment for mobile use. Operated from separate vibrator-type power supply giving 300 volts at 100 ma. Oscillator-doubles uses 6J6 valve. Final amplifier valve is type 6C4. Speech amplifier is 6C4 transformer-coupled to 6J6 modulator. Transmitter is contained in a cabinet measuring 8½ in. x 7 in. x 2¾ in. Oscillator is controlled by 20-metre crystal. Grid resistor bias for doubler and final amplifier.

—Radio News (U.S.A.), July, 1949, p. 32.

A Modern Mobile Transceiver. For 144 m/c. (amateur) band. Power supply from broadcast receiver in car. Transmitter section uses two 7F8 (dual-triode) valves, one as oscillator-tripler—the oscillator being crystal controlled at 48 m/cs—and the other as a push-pull Class C amplifier. Receiver is super-regenerative superheterodyne with one I.F. stage at 10.7 m/cs. Receiver is remotely tuned by a separate unit, which contains the receiver's local oscillator, connected by coaxial cable to the receiver. Receiver's audio system acts as modulator.

—Radio News (U.S.A.), July, 1949, p. 41.

MISCELLANEOUS:

Build Your Own Geiger Counter. Circuit and construction of (a) laboratory type and (b) portable Geiger counter.

—Radio News (U.S.A.), July, 1949, p. 2.

Summary of the proposed new rules and regulations affecting amateur transmitters in U.S.A. as drawn up by the Federal Communications Commission.

—Radio News (U.S.A.), July, 1949, p. 60.

Fresh progress in dry batteries. The Vidor "Kalium" cell. Details of composition, performance, and chemical action in a newly developed (English) dry cell with certain points of resemblance to the Ruben-Mallory (U.S.) cell (see Radio and Electronics Abstracts, August, 1948, p. 48). Negative electrode is zinc, electrolyte caustic potash (KOH), depolarizer mercuric oxide (HgO). Negative electrode is the zinc can and positive electrode is central carbon rod. E.M.F. approximately 1.4v. open circuit, 1.10-1.25 on load. E.M.F. remains constant under heavy loads. Disadvantage of cell is that it is more expensive to manufacture than a Leclanche type owing to comparatively high cost of mercury.

—Wireless World (Eng.), October, 1948, p. 352.

Modern design features of C.B.S. Studio audio facilities. Description of control consoles in modern U.S. broadcast station, considerations involved in design, new features and a suggestion that many fundamental ideas are applicable to services other than broadcasting.

—Proc.I.R.E. (U.S.A.), June, 1948, p. 778.

R.M.A. (U.S.A.) standards. Electrical performance standards for TV broadcast transmitters for 44-216 mc

—Proc.I.R.E. (U.S.A.), July, 1948, p. 932.

Repairing mechanical gramophones. Various hints to enable repairs to be made to spring-driven gramophones.

—Service (U.S.A.), July, 1948, p. 14.

Electromagnetic waves in wave-guides, Part 2. Coaxial cables and circular wave-guides. Theory of propagation is developed in the light of Maxwell's differential equations.

—Philips Tech. Review (Holland), Vol. 10, No. 2, p. 46.

Stabilized power supplies. Circuits and practical design details for the series-valve type of stabilized supply. First part of article.—**Wireless World (Eng.), October, 1948, p. 373.**

Electronic circuitry. (1) Improved "flip-flop" circuit using valve types ECC32 (or 6N7), EF50, and EA50. (2) Simple time delay flip-flop using valve ECC32 (or 6N7). (3) Valve-controlled relay.

—Wireless World (Eng.), October, 1948, p. 379.

Negative frequency. In synchrodyne receiver the carrier-wave frequency of the incoming signal is shifted to zero by a frequency changer; the lower sideband is then negative. Also, a signal modulated by one of a higher frequency gives a different frequency which is negative. Article gives clear explanation, with illustrative examples, of the meaning of the term "negative frequency."

A Compact Home-built Stroboscope. Simply constructed unit incorporating type 1D21 (Sylvania) Strobotron. Several purposes explained. Circuit details.

—Radio News (U.S.A.), March, 1949, p. 90.

Stable Time and Frequency Standard. Article explaining use by National Bureau of Standards (U.S.) of spectral absorption of microwaves by ammonia gas at 23,870.13 mc. as primary standard of time in a new clock.

—Electronics (U.S.A.), April, 1949, p. 82.

PROPAGATION:

Attenuation Between Parabaloid Antennae. Table to provide method of calculating line-of-sight space attenuation between two parabaloid antennae. Adaptable for use with other shapes.

—Electronics (U.S.A.), July, 1949, p. 114.

RECEPTION AND RECEIVERS:

A Fixed-tuned Plug-in Converter. Circuit and construction of a plug-in unit by means of which image response in receivers may be reduced. Unit replaces existing converter stage of receiver and provides double-conversion, with first I.F. of 1500 kc. 6K8 type valves are used as first and second converters. Oscillator portion of second converter is crystal-controlled at 1960 kc., but this feature is not an essential one. Unit is compact and, with receiver for which it was designed, plugs into existing converter valve socket.

—QST (U.S.A.), July, 1949, p. 62.

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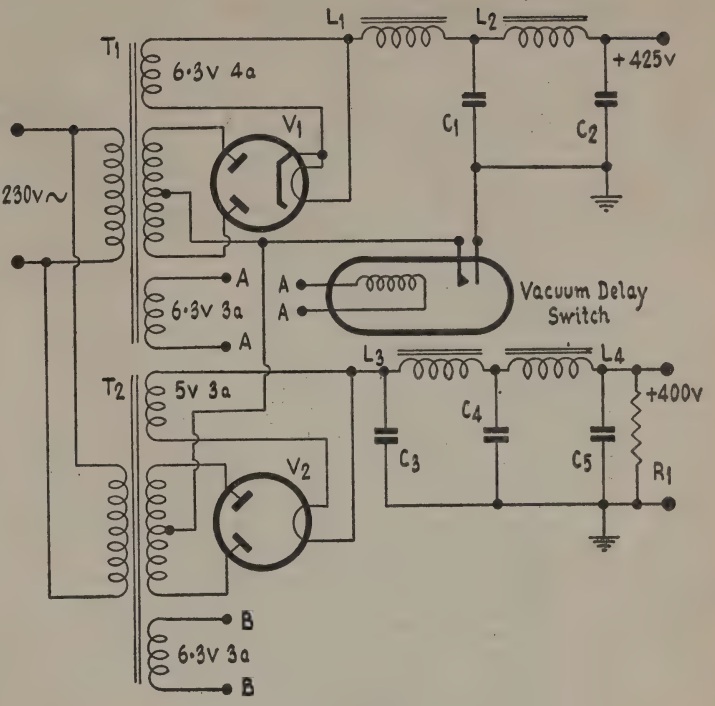
(Continued from page 25.)

valve. The easiest way to look after this is to use a thermal delay switch, in the manner shown in the circuit diagram. This has only a single make-and-break, so that, to switch both supplies simultaneously, the transformer centre-taps of the supplies are connected together and taken to one contact of the switch. The other contact being earthed, no output voltage appears from either supply until the switch closes and completes the negative return for the rectifiers. By this method, there is no possibility of the voltages being applied other than simultaneously, so that all danger of damage is eliminated.

If it is decided not to use a thermal delay switch, one must take care that the plate supply is switched on before the screen supply, and this should preferably be done by means of a relay, energized by the plate supply, with the contacts so arranged that unless the plate supply has been turned on the screen supply cannot come on.

The rectifier used for the plate supply is an AX50. This is a full-wave gas-filled rectifier with a 4v. filament. When the drawing was made, it had been hoped that a rectifier with a 6.3v. filament would be available



T_1, T_2, L_1, R_1, see text.
V_1, AX50 (see text).
V_2, AZ50 (see text).
L_2, 200 ma. smoothing.
L_3, L_4, 80 ma. smoothing.
C_1, 4 μf. 1000v. oil filled.
C_2, 16 μf. 500v. electro.
C_3, C_4, C_5, 8 to 16 μf. 450v. electro.

Unfortunately, however, we had to revert to the AX50, because supplies of the other type will not be forthcoming after all. As a result, the circuit needs amending as far as the voltage rating of the rectifier filament windings are concerned. The AX50 takes a filament current of 3.75 amps. at 4 volts. The stock power transformer we have been recommending has on it a 5-volt winding rated at 3 amps. This was not shown on the diagram, as it was not needed in the original set-up with the 6.3-volt rectifier. Although the AX50 draws more current than the winding is rated at, there will be sufficient leeway to allow it to be used. The 4 volts can be obtained from the 5-volt winding by adding a resistor of 0.27 ohms in series with the filament of the AX50. This resistor can be made from a short length of nichrome heater wire, and can be adjusted by placing an A.C. voltmeter across the valve filament and reducing the length of resistance wire until the meter reads 4 volts under load. If desired, of course, a small 4-volt filament transformer can be used instead, or an auto-transformer wound and attached to the 5-volt winding. If the latter scheme is used, care must be taken to see that the insulation of the auto-transformer will stand up to at least 700 volts D.C. indefinitely.

The rectifier for the screen supply is an AZ50, which is a vacuum full-wave rectifier with a filament rated at 4v., 2a. This can be run from the 5-volt rectifier filament winding of the 80 ma. transformer, with a series resistor of 0.33 ohms that can be made as described above.

For those who are not familiar with the thermal delay switch, it should perhaps be described in more detail. It is enclosed in an evacuated glass envelope, and consists of a bi-metal strip round which is wound a 6.3-volt heater winding. The end of the bi-metal strip carried the movable switch contact, and, after the supplies are switched on, the strip bends under the action of the heater, until, after a predetermined delay period, the contacts close. The make used in our prototype can be purchased with delay times from 25 to 80 seconds. The delay is fixed by the maker, and cannot be altered thereafter. A suitable delay, during which the modulator's cathodes heat up, is 50 seconds or greater. In this way, the modulators are hot by the time the supplies are applied to plate and screen, thus preventing their being operated on no load, waiting for the cathodes to become hot.

The delay switch has been drawn with contacts separate from the heater winding, but it may be possible to get only the kind in which one side of the heater is connected to one terminal of the switch. This kind could not be used except in the negative leg of a power supply unless a separate heater winding were provided for it. As far as circuit changes are concerned, the only difference that this type would make would be that one of the leads marked "A" on the diagram would be connected to the earthed switch contact internally.

This should be remembered when wiring up the modulator chassis, since it will be desired to use the winding A-A for heating some of the valves. In this case, care should be taken NOT to ground one side of the winding on the modulator chassis unless it is identified first as the one that is grounded in the power supply unit.

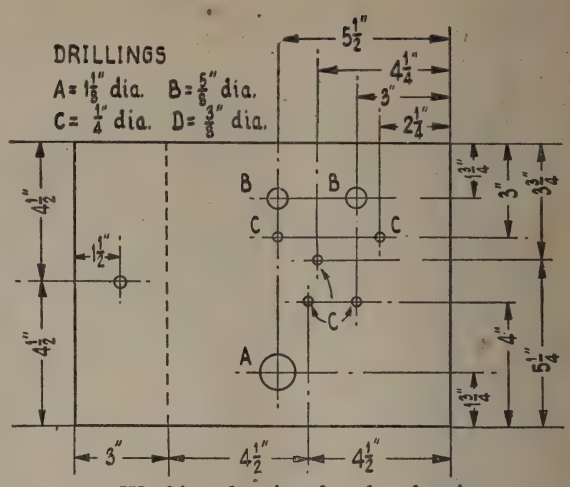
80-40-20 TUNER

(Continued from page 7.)

circuits, and this is very easily done if our recommended coil designs are adhered to. Even here, the band is so narrow that if perfect tracking were not obtained, the fact would never be noticeable except by the aid of instruments. Once the 80-metre circuits have been aligned (and this is very simple), there is no question of alignment on the other bands because all their adjustment consists in setting their circuits to the required fixed frequencies.

CIRCUIT IN DETAIL

As was mentioned above, the R.F. stage uses a 6BA6, for reasons already given. The main oscillator-mixer valve is a new type that is not very well known as yet, the ECH21. This is a loctal-based triode-heptode, which has a remarkable performance. Its conversion conductance is very high—750 micromhos—and for a multi-grid oscillator-mixer valve, its equivalent noise-resistance is remarkably low at 55,000 ohms. Thus, in conjunction with a high-gain R.F. stage, it can be expected to perform very well indeed. Of course, there is no need to use this type if an older valve is preferred, because the circuit is quite conventional, and lends itself to the use of any normal tube such as the 6K8, 6A8, ECH35, or ECH41. We do not, however, advise the use of the 6A8, because the frequency of this type is not nearly so good as



Working drawing for the chassis.

that of the others mentioned, and if it were used it would be advisable to take off the A.V.C. from it.

The extra oscillator-mixer, used only on 40 and 20, has been made a 6J6, because, on the higher frequencies, the stage gain of the R.F. amplifier cannot be expected to be so high as on 80, with the result that two multi-element mixer valves one after the other would be inclined to introduce more set noise than is desirable. The 6J6 is used, half as a triode mixer and the other half as the fixed oscillator. Its valve noise is negligible, and yet it has useful conversion gain, with the result that the whole unit actually has a better signal-to-noise ratio on 20 metres than on 80. This is a highly desirable state of affairs, and could not have been brought about except by the use of a triode for the extra mixer.

It has not been easy to draw the circuit so that it looks as simple as it really is, on account of the large number of switch wafers necessary. Since only three bands are involved, the wave-change switch needs only three positions, but there are nine individual switches, necessitating five wafers. Of the nine wafers used, three are taken up by the special aerial coupling system that has been used, so that only six are directly associated with the valve circuits. If we detail the functions of the various individual switches, it will be quite easy to follow the circuit.

S_1 switches the R.F. grid circuit to the various bands. The fact that the R.F. section of the gang is used only on one band does not add any complication to this part of the circuit at all. The 80-metre band is the one in which the switches are drawn. The gang sections are C_1, C_2, and C_3.

S_2, S_3, and S_4 switch the aerial input terminals. We will have more to say about this part of the circuit later, but at the moment it does not concern us.

S_5 switches the plate circuit of the R.F. amplifier. It will be noted at this point that the coils are connected directly in the plate circuit, no primaries being used. This simplifies the switching and gives higher gain than transformer coupling, especially at the higher frequencies. L_1 is the 80-metre R.F. plate coil, and C_9 is its trimmer. In the 80-metre position of the switch, as drawn, the unmarked blocking condenser directly under S_5 connects the second gang section to the plate of V_1, via the connecting link between S_6 and S_7. The gang section, C_2, is thus able to tune L_1 in the 80-metre position.

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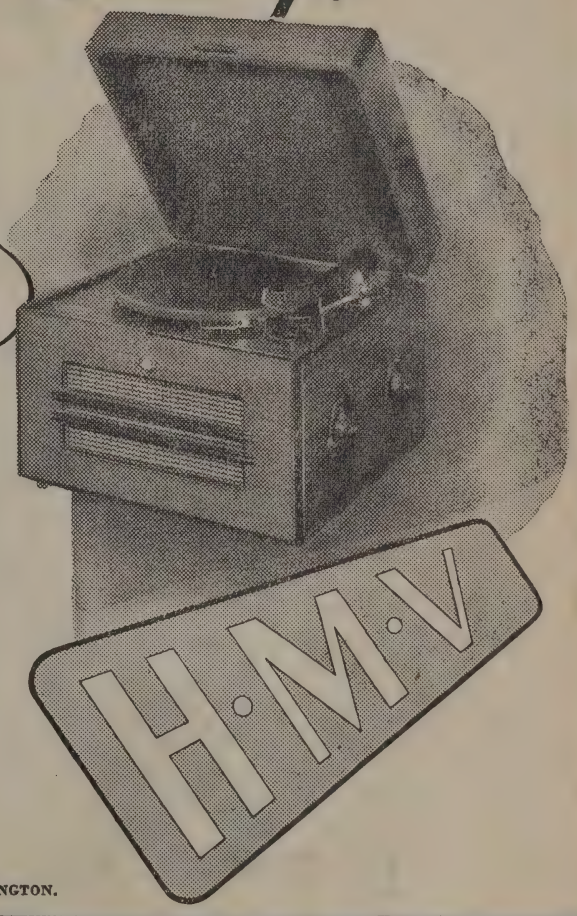

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S_6 switches the grid circuit of the extra mixer, V_3. In the 80-metre position, when V_3 does not work, it short-circuits the V_3 grid to earth. In the 40m. and 20m. positions, it connects the plate of V_1, via the same blocking condenser, to the grid of V_3.

S_7 switches the grid circuit of V_2. On 80m., the grid is connected, through the link with S_6, to the plate of V_1. On 40m. and 20m., the V_2 grid is connected via the blocking condenser, C_{22}, to the plate of V_3, in which is connected the 80-metre coil, L_4, and its trimmer, C_8. Thus, the V_2 grid circuit is tuned to 80 metres on all bands, L_4 and L_1 being identical 80-metre coils.

S_8 switches the oscillator plate of V_3. On the 80-metre position, no oscillator coil is present, so that there is no H.T. applied to the oscillator plate.

S_9 switches the oscillator grid circuit of V_3, thus completing the switching arrangements.

(To be continued.)

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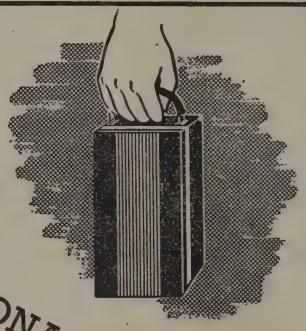

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* * *

Messrs. Arnold & Wright announce their appointment as New Zealand agents for "CLIX" products of British Mechanical Productions, Ltd., England.

* * *

DENCO CT4 TURRET

Rhodes Radio and Electrical Supplies, Auckland, advise that a leaflet is now available giving the required technical data on this communication tuning unit.

PUBLICATIONS RECEIVED

Recently received from the Radio Industry Council, London, is a booklet entitled "British Radio for the World." This was prepared as an invitation to overseas buyers to Radiolympia, London, and comprises articles contributed by editors of the leading United Kingdom radio publications, as well as one by Sir Edward Appleton, late secretary of the United Kingdom Department of Scientific and Industrial Research, and Dr. A. L. Smith-Rose, Director of Radio Research in the same department. In the foreword, when referring to trade papers, the chairman of the Radio Industry Council remarks that "they are among our best friends because they are also our severest critics," and he commends these articles to the overseas reader.

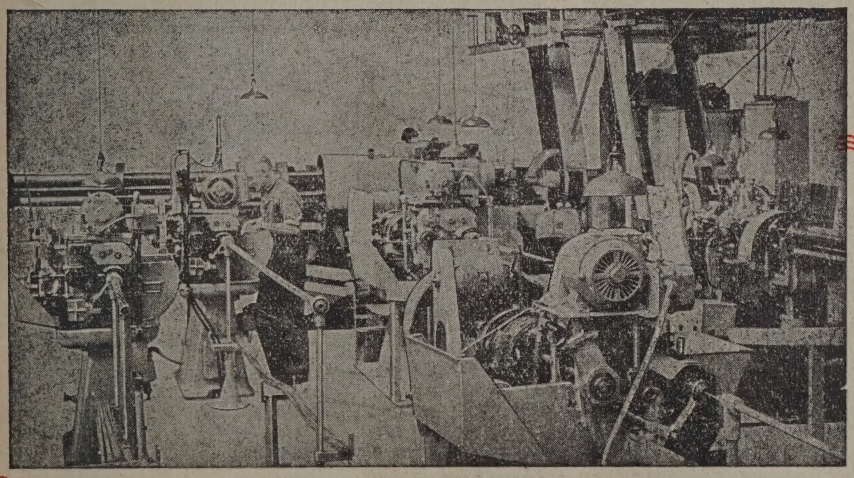
* * *

Rhodes Radio and Electrical Supplies, Auckland, announce that a booklet entitled "Brierley Ribbon and Armature Pickups" is now available. This booklet describes the general principles, specifications, and response curves, etc., for the "Brierley" pickups.

* * *

AUCKLAND MANUFACTURERS' ASSOCIATION—RADIO TRADE GROUP

At the annual meeting held on 29th September, the following new executive was elected for the ensuing year: Mr. T. Spencer (new President), Mr. D. Clifton Lewis (new Vice-President), Mr. G. A. Wooller.



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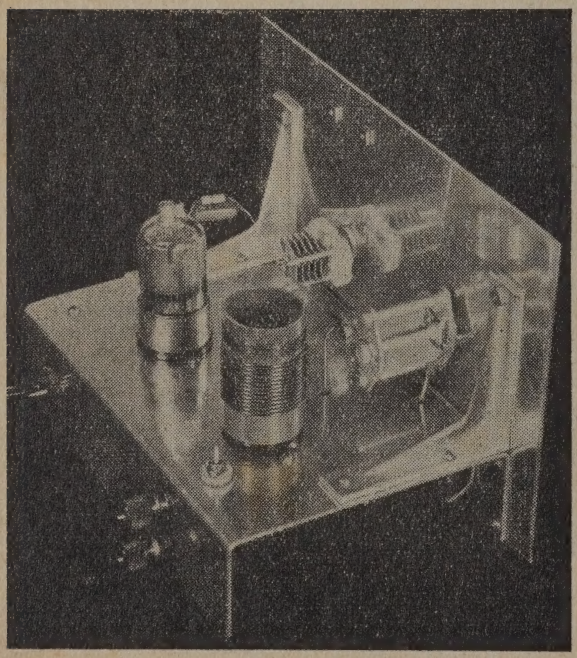
A Practical Beginners' Course

PART 36: CONSTRUCTING THE 6J7 SHORTWAVE SET

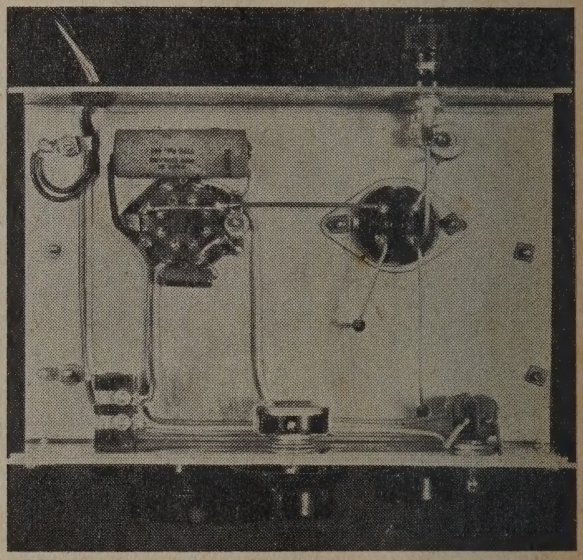
In the last instalment of the Beginners' Course we described the circuit of a simple one-valve shortwave set. This uses an A.C. valve, the 6J7, in order to introduce heater-cathode types to readers, and to give a set which, with only 45 volts of B battery, will give clear reception on a good aerial from all over the world, and will give suprising DX results even on a small outdoor aerial. The purpose of this instalment is to describe the construction in some detail, since this is the first set we have tackled, built on a metal chassis. The two photographs show the construction very clearly. The chassis is made of 16-gauge aluminium sheet, which is light, strong, and easy to work. The only tools needed to make it are a hacksaw, a file, and a breast drill with bits of various sizes. If you do not have a workshop of your own, a friend who has these simple tools will no doubt be pleased to help. The chassis itself is a simple flat sheet bent into a "U" and bolted to the panel, which is a flat sheet.

The rather professional appearance of the original



is due to the use of aluminium brackets, purchased from a chain store, to stiffen the whole chassis. These brackets are bolted to the chassis and also to the panel, and make a very rigid job. **This is very important if the set is to be easy to tune.** The two tuning condensers can be seen mounted on the panel. The large one has three threaded distance pieces into which screws are inserted from the panel, while the small one has a single-hole mounting, and requires a $\frac{3}{8}$ in. hole. The main dial is attached to the bandspread, or small tuning condenser, while the large, or band-setting condenser needs only a plain knob, as it is used only for coarse tuning, the exact tuning being done with the small condenser, which therefore has the better dial. There is no need to use a vernier drive or slow-motion dial, as tuning will be easy enough without it.

The coils are plugged into a four-pin valve socket, mounted in front of the 100 $\mu\mu$f. tuning condenser, and the wiring to this socket can be seen in the underchassis photograph. The wiring has been done with heavy (16-gauge) tinned copper wire for the sake of rigidity. The tap on L_2 is connected to pin number 2, from which the wire can be seen running across the chassis to the cathode and suppressor pins of the valve socket. From pin number 4 wires can be seen going to the earth terminal and through a hole near the on/off switch to the frame of the 100 $\mu\mu$f. tuning condenser. From pin number 1 a wire passes through a small hole in the chassis near the coil socket. Both these wires can be seen in both photographs. The remaining pin on the coil socket is connected to the aerial series condenser. The 0.1 μf. screen bypass condenser can be seen wired right at the valve socket. The earthed lead is soldered to a



lug which is fixed under one of the valve socket's mounting screws. The grid circuit is completed above the chassis, where the grid leak and grid condenser, in parallel, can be seen, wired between the grid cap of the valve and the fixed plates of the bandspread condenser.

The connection between the two tuning condensers is hardly discernible in the photograph, but is made between the two sets of fixed plates, also by a piece of 16-gauge tinned copper wire. The on/off switch was not shown on the circuit diagram, but is wired in one of the heater leads. The B battery lead is not broken by the switch, because when the valve is cold, no plate current can flow. However, if the set is to remain switched off for more than a few minutes, the B lead should be removed from the battery, because current can still flow through the 50k. potentiometer, and would slowly discharge the battery if left on continuously.

(To be continued.)

NEW PRODUCTS : LATEST RELEASES IN ELECTRONIC EQUIPMENT

COURTENAY MODEL 61 "SUSSEX"
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The model 61 "Sussex" is the latest release in the Courtenay range of radio-gramophone models, and has a number of very pleasing features. This set is not designed for the low-price group, but was put into production in response to a demand for a "better than usual" table radio-gram.

This receiver consists of six valves on a one-piece pressed chassis in the following arrangement: 6U7G, R.F. amp.; 6K8G, mixer-osc.; 6U7G, I.F. amp.; 6Q7-GT, audio amp./diode det./A.V.C.; 6V6-GT, tetrode power output; 5Y3-GT, rectified.

Features include high sensitivity (better than 1 μv. over the broadcast band and 2-4 μv. on shortwave), excellent signal-to-noise ratio, Meissner filter system giving extraordinarily low hum level, and high-flux 8 in. P.M. speaker.

Band coverage: Broadcast, 550/1600 kc/sec, and bandspread shortwave 9.4-15.8 mc/sec., giving complete coverage on the 31, 25, and 19-metre bands.

The gram unit is a Collaro, with automatic stop and start and magnetic pick-up with reversible head. The cabinet is walnut veneer, and a feature is the flush-fitting lid, giving the unit a very neat appearance when closed.

Already selling well, it is expected that a steady demand will be found for this model.

ANOTHER AUSTRALIAN VALVE DEVELOPMENT: A.W.V. TYPE 6AR7-GT

Of great interest to the trade, particularly to manufacturers of receivers that have to be built with an eye to economy, is the release of the latest octal-based Radiotron, type 6AR7-GT. Designed and made by Amalgamated Wireless Valve Co. Pty., Ltd., Sydney, 6AR7-GT is a high-gain duo-diode pentode especially applicable to I.F. and detector stages where its high mutual conductance of 2500 μmhos, coupled with a high plate resistance, will give enhanced sensitivity. Shielded internally and externally, this valve makes it possible to obtain I.F. stage gains of over

100 in "straight" sets and over 3000 times in reflex receivers. As a result, it is expected that 6AR7-GT will supersede the older types 6G8G, 6B8G, 6B7, etc. Other types now available from A.W.V. include X61M and KT61. Full details, including data on characteristics, etc., can be obtained from any branch of the New Zealand distributors, the National Electrical and Engineering Co., Ltd.

SOUND MIRROR

Giles & Elliott, Ltd., who were the first importers of magnetic tape recording equipment in to New Zealand, report that the sound mirrors being manufactured in the United Kingdom under licence to Brush Development Co., Cleveland, Ohio, U.S.A., are now in production. In order to have a sample to exhibit, this enterprising firm lost no time in having one consigned by air freight from the United Kingdom, and this is now on display at their warehouse, 9–11 Blair Street, Wellington.

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(Continued on page 48.)

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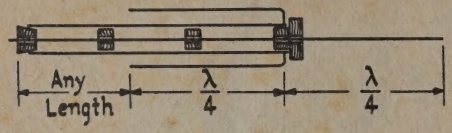
(Continued from page 13.)

voltage minimum point on the line, and the twisted pair is bent round from the other end and soldered to the connecting lug for the inner of the feed line and to the spring-brass connector for the outer.

By means of a slight dodge, the same aerial is made to do for the receiver as well as for the transmitter. A twisted pair is tapped on to the receiver hairpin loop. One connection is at the exact centre, while the other is about half an inch down from the centre towards the plate connection. At the other end of the short twisted pair is a loop, similar to that used to couple the transmitter to the aerial. This loop is coupled to the transmitter line also, so that on "receive," the transmitter tuned circuit acts as a tuned aerial circuit, to which the receiver feed line is coupled. On "transmit," the receiver circuit receives R.F. voltage from its coupling to the transmitter's line, but this does not matter, as the receiver circuit is so arranged that not even grid current can flow when H.T. is switched off. This system of aerial coupling is quite efficient, but can only be used in a case like this where the transmitter power is so low that no damage can occur to the receiver circuit when the transmitter is working.



Diagrammatic representation of the aerial used with the transmitter-receiver. The shaded portions represent perspex or polystyrene insulating beads. The construction is described in the text.

In next month's issue we hope to give the results of some practical tests of this equipment, actually on the air. Some of these tests have already been carried out, with notable success, so that there is no doubt that the system really works—in the field, as well as on the bench.

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(Continued from previous page.)

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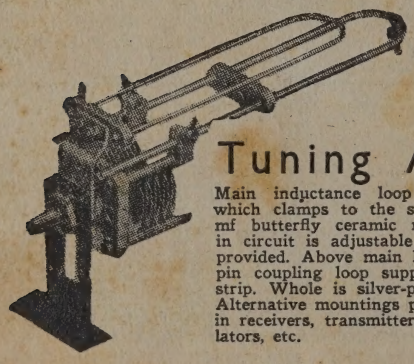

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